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Best Demonstrated Available Technology (BDAT) Background Document for K061

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BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT) BACKGROUND DOCUMENT FOR

K061
(IRON AND STEEL INDUSTRY)

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BDAT Treatment Standards for K061

Pursuant to the Hazardous and Solid Waste Amendments (HSWA) enacted on November 8, 1984, and in accordance with the procedures for establishing treatment standards under Section 3004(m) of the Resource, Conservation and Recovery Act (RCRA), the Environmental Protection Agency (EPA) is proposing treatment standards for the listed waste, K061, based on the performance of a recovery technology determined by the Agency to represent Best Demonstrated Available Technology (BDAT). This background document provides the detailed analyses that support this determination.

These BDAT treatment standards represent maximum acceptable concentration levels for selected hazardous constituents in the wastes or residuals from recovery. The levels are established as a prerequisite for disposal of these wastes in units designated as land disposal units according to 40 CFR Part 268 (Code of Federal Regulations). Wastes that, as generated, contain the regulated constituents at concentrations which do not exceed the treatment standards are not restricted from land disposal units. The Agency has chosen to set levels for these wastes rather than to designate the use of a specific technology.

These proposed standards have an effective date of August 8, 1990. This date reflects a 2 year nationwide variance to the promulgation date due to a lack of nationwide capacity for high temperature metals recovery.

According to 40 CFR Part 261.32 (hazardous wastes from specific sources), waste code K061 is listed as "emission control dust/sludge from the primary production of steel in electric furnaces." Descriptions of the industry and specific processes generating these wastes, as well as, descriptions of the physical and chemical waste characteristics, are provided in Section 2.0 of this document. The four-digit Standard Industrial Classification (SIC) code most often reported for the industry generating this waste code is 3312 (iron and steel production). The Agency estimates that approximately 85 facilities have the potential to generate wastes identified as K061.

The Agency has determined that K061 represents a single treatability group based on its physical and chemical composition, and consists of only one subgroup--nonwastewaters. For the purpose of the land disposal restrictions rule, wastewaters are defined as wastes containing less than 1 percent (weight basis) filterable solids and less than 1 percent (weight basis) total organic carbon (TOC). Wastes not meeting this definition are classified as nonwastewaters. While the Agency has not, at this time, specifically identified additional wastes that would fall into this treatability group or subgroup, this does not preclude the Agency from extrapolating these standards to other wastes in the future.

K061 wastes, as generated, are metallic dusts or sludges with low to moderate water content and low organic content: they are classified as nonwastewaters. Solid residues from the treatment or recycling of K061 wastes also fall into this classification. K061 wastewaters may

potentially be generated primarily as a result of the "derived-from rule" and the "mixture-rule" as outlined in 40 CFR Part 261.3 (definition of hazardous waste). Aqueous residues from inadvertent mixtures of the waste with other wastewaters or aqueous wastes could be classified as K061 wastewaters. Since the Agency has not identified any K061 wastewaters, EPA is proposing "No Land Disposal" as the treatment standard.

The Agency has proposed BDAT treatment standards for the treatability subgroup of K061 wastes identified as nonwastewaters. These treatment standards have been proposed for a total of five metals that the Agency has identified as being present in K061 wastes. These metals include cadmium, chromium, lead, mercury, and zinc. A detailed discussion of the selection of constituents to be regulated is presented in Section 5 of this document.

BDAT treatment standards for nonwastewater K061 have been proposed based on performance data using a high temperature metals recovery process designed to recover zinc oxide from K061 and other scrap materials containing zinc. The Agency has examined additional performance data for treatment of K061 using high temperature metals recovery and stabilization. Analyses of these data indicate that high temperature metals recovery provides more effective treatment than stabilization. In addition, the Agency believes that establishing recovery as the Best Demonstrated Available Technology is consistent with the national policy identified in HSWA by which Congress set up a

hierarchy of waste management alternatives. This hierarchy places source reduction as the first priority of waste management, with recycling as the second priority, treatment as the next, and land disposal as the last.

The following table lists the specific BDAT treatment standards for K061 wastes. The Agency is setting standards based on both the analysis of total concentration and a leachate of the waste for K061 nonwastewaters, but it is not setting standards for K061 wastewaters. The leachate is obtained by use of the Toxicity Characteristic Leaching Procedure (TCLP). The units for total concentration analysis are in parts per million (mg/kg) on a weight by weight basis. The units for leachate analysis are in parts per million (mg/l) on a weight by volume basis. Testing procedures are specifically identified in the quality assurance sections of this document.

BDAT TREATMENT STANDARDS FOR K061*

(As Concentration in Nonwastewater Treatment Residual)

Constituent	Total Concentration (mg/kg)	TCLP Concentration (mg/l)
Cadmium	44	0.19
Chromium	1,730	0.33
Lead	20,300	0.09
Mercury	0.28	0.02
Zinc	24,100	0.50

*Both total concentration and TCLP concentration values must be complied with prior to land disposal.

1. INTRODUCTION

This section of the background document presents a summary of the legal authority pursuant to which the BDAT treatment standards were developed, a summary of EPA's promulgated methodology for developing BDAT, and finally a discussion of the petition process that should be followed to request a variance from the BDAT treatment standards.

1.1 Legal Background

1.1.1 Requirements Under HSWA

The Hazardous and Solid Waste Amendments of 1984 (HSWA), enacted on November 8, 1984, and which amended the Resource Conservation and Recovery Act of 1976 (RCRA), impose substantial new responsibilities on those who handle hazardous waste. In particular, the amendments require the Agency to promulgate regulations that restrict the land disposal of untreated hazardous wastes. In its enactment of HSWA, Congress stated explicitly that "reliance on land disposal should be minimized or eliminated, and land disposal, particularly landfill and surface impoundment, should be the least favored method for managing hazardous wastes" (RCRA section 1002(b)(7), 42 U.S.C. 6901(b)(7)).

One part of the amendments specifies dates on which particular groups of untreated hazardous wastes will be prohibited from land disposal unless "it has been demonstrated to the Administrator, to a reasonable degree of certainty, that there will be no migration of hazardous constituents from the disposal unit or injection zone for as long as the wastes remain hazardous" (RCRA section 3004(d)(1), (e)(1), (g)(5), 42 U.S.C. 6924 (d)(1), (e)(1), (g)(5)).

For the purpose of the restrictions, HSWA defines land disposal "to include, but not be limited to, any placement of . . . hazardous waste in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, salt bed formation, or underground mine or cave" (RCRA section 3004(k), 42 U.S.C. 6924(k)). Although HSWA defines land disposal to include injection wells, such disposal of solvents, dioxins, and certain other wastes, known as the California List wastes, is covered on a separate schedule (RCRA section 3004(f)(2), 42 U.S.C. 6924 (f)(2)). This schedule requires that EPA develop land disposal restrictions for deep well injection by August 8, 1988.

The amendments also require the Agency to set "levels or methods of treatment, if any, which substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste so that short-term and long-term threats to human health and the environment are minimized" (RCRA section 3004(m)(1), 42 U.S.C. 6924 (m)(1)). Wastes that meet treatment standards established by EPA are not prohibited and may be land disposed. In setting treatment standards for listed or characteristic wastes, EPA may establish different standards for particular wastes within a single waste code with differing treatability characteristics. One such characteristic is the physical form of the waste. This frequently leads to different standards for wastewaters and nonwastewaters.

alternatively, EPA can establish a treatment standard that is applicable to more than one waste code when, in EPA's judgment, all the waste can be treated to the same concentration. In those instances where a generator can demonstrate that the standard promulgated for the generator's waste cannot be achieved, the Agency also can grant a variance from a treatment standard by revising the treatment standard for that particular waste through rulemaking procedures. (A further discussion of treatment variances is provided in Section 1.3.)

The land disposal restrictions are effective when promulgated unless the Administrator grants a national variance and establishes a different date (not to exceed 2 years beyond the statutory deadline) based on "the earliest date on which adequate alternative treatment, recovery, or disposal capacity which protects human health and the environment will be available" (RCRA section 3004(h)(2), 42 U.S.C. 6924 (h)(2)).

If EPA fails to set a treatment standard by the statutory deadline for any hazardous waste in the First Third or Second Third of the schedule (see section 1.1.2), the waste may not be disposed in a landfill or surface impoundment unless the facility is in compliance with the minimum technological requirements specified in section 3004(o) of RCRA. In addition, prior to disposal, the generator must certify to the Administrator that the availability of treatment capacity has been investigated and it has been determined that disposal in a landfill or surface impoundment is the only practical alternative to treatment currently available to the generator. This restriction on the use of

landfills and surface impoundments applies until EPA sets a treatment standard for the waste or until May 8, 1990, whichever is sooner. If the Agency fails to set a treatment standard for any ranked hazardous waste by May 8, 1990, the waste is automatically prohibited from land disposal unless the waste is placed in a land disposal unit that is the subject of a successful "no migration" demonstration (RCRA section 3004(g), 42 U.S.C. 6924(g)). "No migration" demonstrations are based on case-specific petitions that show there will be no migration of hazardous constituents from the unit for as long as the waste remains hazardous.

1.1.2 Schedule for Developing Restrictions

Under Section 3004(g) of RCRA, EPA was required to establish a schedule for developing treatment standards for all wastes that the Agency had listed as hazardous by November 8, 1984. Section 3004(g) required that this schedule consider the intrinsic hazards and volumes associated with each of these wastes. The statute required EPA to set treatment standards according to the following schedule:

(a) Solvents and dioxins standards must be promulgated by November 8, 1986;

(b) The "California List" must be promulgated by July 8, 1987;

(c) At least one-third of all listed hazardous wastes must be promulgated by August 8, 1988 (First Third);

(d) At least two-thirds of all listed hazardous wastes must be promulgated by June 8, 1989 (Second Third); and

(e) All remaining listed hazardous wastes and all hazardous wastes identified as of November 8, 1984, by one or more of the characteristics defined in 40 CFR Part 261 must be promulgated by May 8, 1990 (Third Third).

The statute specifically identified the solvent wastes as those covered under waste codes F001, F002, F003, F004, and F005; it identified the dioxin-containing hazardous wastes as those covered under waste codes F020, F021, F022, and F023.

Wastes collectively known as the California List wastes, defined under Section 3004(d) of HSWA, are liquid hazardous wastes containing metals, free cyanides, PCBs, corrosives (i.e., a pH less than or equal to 2.0), and any liquid or nonliquid hazardous waste containing halogenated organic compounds (HOCs) above 0.1 percent by weight. Rules for the California List were proposed on December 11, 1986, and final rules for PCBs, corrosives, and HOC-containing wastes were established August 12, 1987. In that rule, EPA elected not to establish standards for metals. Therefore, the statutory limits became effective.

On May 28, 1986, EPA published a final rule (51 FR 19300) that delineated the specific waste codes that would be addressed by the First Third, Second Third, and Third Third. This schedule is incorporated into 40 CFR 268.10, .11, and .12.

1.2 Summary of Promulgated BDAT Methodology

In a November 7, 1986, rulemaking, EPA promulgated a technology-based approach to establishing treatment standards under section 3004(m). Section 3004(m) also specifies that treatment standards must "minimize" long- and short-term threats to human health and the environment arising from land disposal of hazardous wastes.

Congress indicated in the legislative history accompanying the HSWA that "[t]he requisite levels of [sic] methods of treatment established by the Agency should be the best that has been demonstrated to be achievable," noting that the intent is "to require utilization of available technology" and not a "process which contemplates technology-forcing standards" (Vol. 130 Cong. Rec. S9178 (daily ed., July 25, 1984)). EPA has interpreted this legislative history as suggesting that Congress considered the requirement under 3004(m) to be met by application of the best demonstrated and achievable (i.e., available) technology prior to land disposal of wastes or treatment residuals. Accordingly, EPA's treatment standards are generally based on the performance of the best demonstrated available technology (BDAT) identified for treatment of the hazardous constituents. This approach involves the identification of potential treatment systems, the determination of whether they are demonstrated and available, and the collection of treatment data from well-designed and well-operated systems.

The treatment standards, according to the statute, can represent levels or methods of treatment, if any, that substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents. Wherever possible, the Agency prefers to establish BDAT treatment standards as "levels" of treatment (i.e., performance standards) rather than adopting an approach that would require the use of specific treatment "methods." EPA believes that concentration-based treatment levels offer the regulated community greater

flexibility to develop and implement compliance strategies as well as an incentive to develop innovative technologies.

1.2.1 Waste Treatability Group

In developing the treatment standards, EPA first characterizes the waste(s). As necessary, EPA may establish treatability groups for wastes having similar physical and chemical properties. That is, if EPA believes that wastes represented by different waste codes could be treated to similar concentrations using identical technologies, the Agency combines the codes into one treatability group. EPA generally considers wastes to be similar when they are both generated from the same industry and from similar processing stages. In addition, EPA may combine two or more separate wastes into the same treatability group when data are available showing that the waste characteristics affecting performance are similar or that one waste would be expected to be less difficult to treat.

Once the treatability groups have been established, EPA collects and analyzes data on identified technologies used to treat the wastes in each treatability group. The technologies evaluated must be demonstrated on the waste or a similar waste and must be available for use.

1.2.2 Demonstrated and Available Treatment Technologies

Consistent with legislative history, EPA considers demonstrated technologies to be those that are used to treat the waste of interest or a similar waste with regard to parameters that affect treatment selection (see November 7, 1986, 51 FR 40588). EPA also will consider as treatment those technologies used to separate or otherwise process chemicals and

other materials. Some of these technologies clearly are applicable to waste treatment, since the wastes are similar to raw materials processed in industrial applications.

For most of the waste treatability groups for which EPA will promulgate treatment standards, EPA will identify demonstrated technologies either through review of literature related to current waste treatment practices or on the basis of information provided by specific facilities currently treating the waste or similar wastes.

In cases where the Agency does not identify any facilities treating wastes represented by a particular waste treatability group, EPA may transfer a finding of demonstrated treatment. To do this, EPA will compare the parameters affecting treatment selection for the waste treatability group of interest to other wastes for which demonstrated technologies already have been determined. The parameters affecting treatment selection and their use for this waste are described in Section 3.2 of this document. If the parameters affecting treatment selection are similar, then the Agency will consider the treatment technology also to be demonstrated for the waste of interest. For example, EPA considers rotary kiln incineration a demonstrated technology for many waste codes containing hazardous organic constituents, high total organic content, and high filterable solids content, regardless of whether any facility is currently treating these wastes. The basis for this determination is data found in literature and data generated by EPA confirming the use of rotary kiln incineration on wastes having the above characteristics.

If no commercial treatment or recovery operations are identified for a waste or wastes with similar physical or chemical characteristics that affect treatment selection, the Agency will be unable to identify any demonstrated treatment technologies for the waste, and, accordingly, the waste will be prohibited from land disposal (unless handled in accordance with the exemption and variance provisions of the rule). The Agency is, however, committed to establishing treatment standards as soon as new or improved treatment processes are demonstrated (and available).

Operations only available at research facilities, pilot- and bench-scale operations will not be considered in identifying demonstrated treatment technologies for a waste because these technologies would not necessarily be "demonstrated." Nevertheless, EPA may use data generated at research facilities in assessing the performance of demonstrated technologies.

As discussed earlier, Congress intended that technologies used to establish treatment standards under Section 3004(m) be not only "demonstrated," but also available. To decide whether demonstrated technologies may be considered "available," the Agency determines whether they (1) are commercially available and (2) substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste.

EPA will only set treatment standards based on a technology that meets the above criteria. Thus, the decision to classify a technology as "unavailable" will have a direct impact on the treatment standard. If

the best technology is unavailable, the treatment standard will be based on the next best treatment technology determined to be available. To the extent that the resulting treatment standards are less stringent, greater concentrations of hazardous constituents in the treatment residuals could be placed in land disposal units.

There also may be circumstances in which EPA concludes that for a given waste none of the demonstrated treatment technologies are "available" for purposes of establishing the 3004(m) treatment performance standards. Subsequently, these wastes will be prohibited from continued placement in or on the land unless managed in accordance with applicable exemptions and variance provisions. The Agency is, however, committed to establishing new treatment standards as soon as new or improved treatment processes become "available."

(1) Proprietary or Patented Processes. If the demonstrated treatment technology is a proprietary or patented process that is not generally available, EPA will not consider the technology in its determination of the treatment standards. EPA will consider proprietary or patented processes available if it determines that the treatment method can be purchased or licensed from the proprietor or is commercially available treatment. The services of the commercial facility offering this technology often can be purchased even if the technology itself cannot be purchased.

(2) Substantial Treatment. To be considered "available," a demonstrated treatment technology must "substantially diminish the

toxicity" of the waste or "substantially reduce the likelihood of migration of hazardous constituents" from the waste in accordance with section 3004(m). By requiring that substantial treatment be achieved in order to set a treatment standard, the statute ensures that all wastes are adequately treated before being placed in or on the land and ensures that the Agency does not require a treatment method that provides little or no environmental benefit. Treatment will always be deemed substantial if it results in nondetectable levels of the hazardous constituents of concern. If nondetectable levels are not achieved, then a determination of substantial treatment will be made on a case-by-case basis. This approach is necessary because of the difficulty of establishing a meaningful guideline that can be applied broadly to the many wastes and technologies to be considered. EPA will consider the following factors in an effort to evaluate whether a technology provides substantial treatment on a case-by-case basis:

(a) Number and types of constituents treated;

(b) Performance (concentration of the constituents in the treatment residuals); and

(c) Percent of constituents removed.

If none of the demonstrated treatment technologies achieve substantial treatment of a waste, the Agency cannot establish treatment standards for the constituents of concern in that waste.

1.2.3 Collection of Performance Data

Performance data on the demonstrated available technologies are evaluated by the Agency to determine whether the data are representative

of well-designed and well-operated treatment systems. Only data from well-designed and well-operated systems are included in determining BDAT. The data evaluation includes data already collected directly by EPA and/or data provided by industry. In those instances where additional data are needed to supplement existing information, EPA collects additional data through a sampling and analysis program. The principal elements of this data collection program are: (a) identification of facilities for site visits, (b) engineering site visit, (c) Sampling and Analysis Plan, (d) sampling visit, and (e) Onsite Engineering Report.

(1) Identification of Facilities for Site Visits. To identify facilities that generate and/or treat the waste of concern, EPA uses a number of information sources. These include Stanford Research Institute's Directory of Chemical Producers, EPA's Hazardous Waste Data Management System (HWDMS), the 1986 Treatment, Storage, Disposal Facility (TSDF) National Screening Survey, and EPA's Industry Studies Data Base. In addition, EPA contacts trade associations to inform them that the Agency is considering visits to facilities in their industry and to solicit assistance in identifying facilities for EPA to consider in its treatment sampling program.

After identifying facilities that treat the waste, EPA uses this hierarchy to select sites for engineering visits: (1) generators treating single wastes on site; (2) generators treating multiple wastes together on site; (3) commercial treatment, storage, and disposal facilities

(TSDFs); and (4) EPA in-house treatment. This hierarchy is based on two concepts: (1) to the extent possible, EPA should develop treatment standards from data produced by treatment facilities handling only a single waste, and (2) facilities that routinely treat a specific waste have had the best opportunity to optimize design parameters. Although excellent treatment can occur at many facilities that are not high in this hierarchy, EPA has adopted this approach to avoid, when possible, ambiguities related to the mixing of wastes before and during treatment.

When possible, the Agency will evaluate treatment technologies using commercially operated systems. If performance data from properly designed and operated commercial treatment methods for a particular waste or a waste judged to be similar are not available, EPA may use data from research facilities operations. Whenever research facility data are used, EPA will explain why such data were used in the preamble and background document and will request comments on the use of such data.

Although EPA's data bases provide information on treatment for individual wastes, the data bases rarely provide data that support the selection of one facility for sampling over another. In cases where several treatment sites appear to fall into the same level of the hierarchy, EPA selects sites for visits strictly on the basis of which facility could most expeditiously be visited and later sampled if justified by the engineering visit.

(2) Engineering Site Visit. Once a treatment facility has been selected, an engineering site visit is made to confirm that a candidate for sampling meets EPA's criteria for a well-designed facility and to ensure that the necessary sampling points can be accessed to determine operating parameters and treatment effectiveness. During the visit, EPA also confirms that the facility appears to be well operated, although the actual operation of the treatment system during sampling is the basis for EPA's decisions regarding proper operation of the treatment unit. In general, the Agency considers a well-designed facility to be one that contains the unit operations necessary to treat the various hazardous constituents of the waste as well as to control other nonhazardous materials in the waste that may affect treatment performance.

In addition to ensuring that a system is reasonably well designed, the engineering visit examines whether the facility has a way to measure the operating parameters that affect performance of the treatment system during the waste treatment period. For example, EPA may choose not to sample a treatment system that operates in a continuous mode, for which an important operating parameter cannot be continuously recorded. In such systems, instrumentation is important in determining whether the treatment system is operating at design values during the waste treatment period.

(3) Sampling and Analysis Plan. If after the engineering site visit the Agency decides to sample a particular plant, the Agency will then develop a site-specific Sampling and Analysis Plan (SAP) according to the Generic Quality Assurance Project Plan for the Land Disposal Restriction

Program ("BDAT"), EPA/530-SW-87-011. In brief, the SAP discusses where the Agency plans to sample, how the samples will be taken, the frequency of sampling, the constituents to be analyzed and the method of analysis, operational parameters to be obtained, and specific laboratory quality control checks on the analytical results.

The Agency will generally produce a draft of the site-specific Sampling and Analysis Plan within 2 to 3 weeks of the engineering visit. The draft of the SAP is then sent to the plant for review and comment. With few exceptions, the draft SAP should be a confirmation of data collection activities discussed with the plant personnel during the engineering site visit. EPA encourages plant personnel to recommend any modifications to the SAP that they believe will improve the quality of the data.

It is important to note that sampling of a plant by EPA does not mean that the data will be used in the development of treatment standards for BDAT. EPA's final decision on whether to use data from a sampled plant depends on the actual analysis of the waste being treated and on the operating conditions at the time of sampling. Although EPA would not plan to sample a facility that was not ostensibly well-designed and well-operated, there is no way to ensure that at the time of the sampling the facility will not experience operating problems. Additionally, EPA statistically compares its test data to suitable industry-provided data, where available, in its determination of what data to use in developing treatment standards. The methodology for comparing data is presented later in this section.

(Note: Facilities wishing to submit data for consideration in the development of BDAT standards should, to the extent possible, provide sampling information similar to that acquired by EPA. Such facilities should review the Generic Quality Assurance Project Plan for the Land Disposal Restriction Program ("BDAT"), which delineates all of the quality control and quality assurance measures associated with sampling and analysis. Quality assurance and quality control procedures are summarized in Section 1.2.6 of this document.)

(4) Sampling Visit. The purpose of the sampling visit is to collect samples that characterize the performance of the treatment system and to document the operating conditions that existed during the waste treatment period. At a minimum, the Agency attempts to collect sufficient samples of the untreated waste and solid and liquid treatment residuals so that variability in the treatment process can be accounted for in the development of the treatment standards. To the extent practicable, and within safety constraints, EPA or its contractors collect all samples and ensure that chain-of-custody procedures are conducted so that the integrity of the data is maintained.

In general, the samples collected during the sampling visit will have already been specified in the SAP. In some instances, however, EPA will not be able to collect all planned samples because of changes in the facility operation or plant upsets; EPA will explain any such deviations from the SAP in its follow-up Onsite Engineering Report.

(5) Onsite Engineering Report. EPA summarizes all its data collection activities and associated analytical results for testing at a facility in a report referred to as the Onsite Engineering Report (OER). This report characterizes the waste(s) treated, the treated residual concentrations, the design and operating data, and all analytical results including methods used and accuracy results. This report also describes any deviations from EPA's suggested analytical methods for hazardous wastes (Test Methods for Evaluating Solid Waste, SW-846, Third Edition, November 1986).

After the Onsite Engineering Report is completed, the report is submitted to the plant for review. This review provides the plant with a final opportunity to claim any information contained in the report as confidential. Following the review and incorporation of comments, as appropriate, the report is made available to the public with the exception of any material claimed as confidential by the plant.

1.2.4 Hazardous Constituents Considered and Selected for Regulation

(1) Development of BDAT List. The list of hazardous constituents within the waste codes that are targeted for treatment is referred to by the Agency as the BDAT constituent list. This list, provided as Table 1-1, is derived from the constituents presented in 40 CFR Part 261, Appendix VII and Appendix VIII, as well as several ignitable constituents used as the basis of listing wastes as F003 and F005. These sources provide a comprehensive list of hazardous constituents specifically regulated under RCRA. The BDAT list consists of those constituents that can be analyzed using methods published in SW-846, Third Edition.

Table 1-1 BDAT Constituent List

BDAT reference no	Parameter	CAS no.
	Volatiles	
222	Acetone	67-64-1
1	Acetonitrile	75-05-8
2	Acrolein	107-02-8
3	Acrylonitrile	107-13-1
4.	Benzene	71-43-2
5	Bromodichloromethane	75-27-4
6	Bromomethane	74-83-9
223.	n-Butyl alcohol	71-36-3
7.	Carbon tetrachloride	56-23-5
8	Carbon disulfide	75-15-0
9	Chlorobenzene	108-90-7
10.	2-Chloro-1,3-butadiene	126-99-8
11.	Chlorodibromomethane	124-48-1
12.	Chloroethane	75-00-3
13.	2-Chloroethyl vinyl ether	110-75-8
14.	Chloroform	67-66-3
15	Chloromethane	74-87-3
16	3-Chloropropene	107-05-1
17.	1,2-Dibromo-3-chloropropane	96-12-8
18.	1,2-Dibromoethane	106-93-4
19	Dibromomethane	74-95-3
20	Trans-1,4-Dichloro-2-butene	110-57-6
21	Dichlorodifluoromethane	75-71-8
22	1,1-Dichloroethane	75-34-3
23.	1,2-Dichloroethane	107-06-2
24.	1,1-Dichloroethylene	75-35-4
25.	Trans-1,2-Dichloroethene	156-60-5
26	1,2-Dichloropropane	78-87-5
27.	Trans-1,3-Dichloropropene	10061-02-6
28.	cis-1,3-Dichloropropene	10061-01-5
29	1,4-Dioxane	123-91-1
224	2-Ethoxyethanol	110-80-5
225	Ethyl acetate	141-78-6
226	Ethyl benzene	100-41-4
30	Ethyl cyanide	107-12-0
227	Ethyl ether	60-29-7
31	Ethyl methacrylate	97-63-2
214	Ethylene oxide	75-21-8
32.	Iodomethane	74-88-4

Table 1-1 (continued)

BDAT reference no	Parameter	CAS no.
	Volatiles (continued)	
33	Isobutyl alcohol	78-83-1
228.	Methanol	67-56-1
34	Methyl ethyl ketone	78-93-3
229	Methyl isobutyl ketone	108-10-1
35	Methyl methacrylate	80-62-6
37	Methacrylonitrile	126-98-7
38	Methylene chloride	75-09-2
230.	2-Nitropropane	79-46-9
39	Pyridine	110-86-1
40	1,1,1,2-Tetrachloroethane	630-20-6
41	1,1,2,2-Tetrachloroethane	79-34-6
42.	Tetrachloroethene	127-18-4
43	Toluene	108-88-3
44	Tribromomethane	75-25-2
45.	1,1,1-Trichloroethane	71-55-6
46	1,1,2-Trichloroethane	79-00-5
47.	Trichloroethene	79-01-6
48.	Trichloromonofluoromethane	75-69-4
49	1,2,3-Trichloropropane	96-18-4
231.	1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1
50	Vinyl chloride	75-01-4
215	1,2-Xylene	97-47-6
216.	1,3-Xylene	108-38-3
217.	1,4-Xylene	106-44-5
	Semivolatiles	
51	Acenaphthalene	208-96-8
52.	Acenaphthene	83-32-9
53	Acetophenone	96-86-2
54	2-Acetylaminofluorene	53-96-3
55	4-Aminobiphenyl	92-67-1
56	Aniline	62-53-3
57.	Anthracene	120-12-7
58	Aramite	140-57-8
59.	Benz(a)anthracene	56-55-3
218	Benzal chloride	98-87-3
60	Benzenethiol	108-98-5
61	Deleted	
62.	Benzo(a)pyrene	50-32-8

Table 1-1 (continued)

BDAT reference no	Parameter	CAS no.
	Semivolatiles (continued)	
63	Benzo(b)fluoranthene	205-99-2
64.	Benzo(ghi)perylene	191-24-2
65.	Benzo(k)fluoranthene	207-08-9
66.	p-Benzoquinone	106-51-4
67.	Bis(2-chloroethoxy)methane	111-91-1
68.	Bis(2-chloroethyl)ether	111-44-4
69.	Bis(2-chloroisopropyl)ether	39638-32-9
70.	Bis(2-ethylhexyl)phthalate	117-81-7
71	4-Bromophenyl phenyl ether	101-55-3
72.	Butyl benzyl phthalate	85-68-7
73	2-sec-Butyl-4,6-dinitrophenol	88-85-7
74.	p-Chloroaniline	106-47-8
75.	Chlorobenzilate	510-15-6
76	p-Chloro-m-cresol	59-50-7
77.	2-Chloronaphthalene	91-58-7
78.	2-Chlorophenol	95-57-8
79.	3-Chloropropionitrile	542-76-7
80.	Chrysene	218-01-9
81	ortho-Cresol	95-48-7
82	para-Cresol	106-44-5
232	Cyclohexanone	108-94-1
83.	Dibenz(a,h)anthracene	53-70-3
84.	Dibenzo(a,e)pyrene	192-65-4
85.	Dibenzo(a,i)pyrene	189-55-9
86.	m-Dichlorobenzene	541-73-1
87	o-Dichlorobenzene	95-50-1
88	p-Dichlorobenzene	106-46-7
89	3,3'-Dichlorobenzidine	91-94-1
90.	2,4-Dichlorophenol	120-83-2
91	2,6-Dichlorophenol	87-65-0
92.	Diethyl phthalate	84-66-2
93	3,3'-Dimethoxybenzidine	119-90-4
94	p-Dimethylaminoazobenzene	60-11-7
95.	3,3'-Dimethylbenzidine	119-93-7
96	2,4-Dimethylphenol	105-67-9
97.	Dimethyl phthalate	131-11-3
98	Di-n-butyl phthalate	84-74-2
99.	1,4-Dinitrobenzene	100-25-4
100.	4,6-Dinitro-o-cresol	534-52-1
101	2,4-Dinitrophenol	51-28-5

Table 1-1 (continued)

BDAT reference no	Parameter	CAS no.
	Semivolatiles (continued)	
102	2,4-Dinitrotoluene	121-14-2
103	2,6-Dinitrotoluene	606-20-2
104	Di-n-octyl phthalate	117-84-0
105	Di-n-propylnitrosamine	621-64-7
106	Diphenylamine	122-39-4
219	Diphenylnitrosamine	86-30-6
107	1,2-Diphenylhydrazine	122-66-7
108	Fluoranthene	206-44-0
109.	Fluorene	86-73-7
110	Hexachlorobenzene	118-74-1
111	Hexachlorobutadiene	87-68-3
112.	Hexachlorocyclopentadiene	77-47-4
113	Hexachloroethane	67-72-1
114.	Hexachlorophene	70-30-4
115	Hexachloropropene	1888-71-7
116	Indeno(1,2,3-cd)pyrene	193-39-5
117.	Isosafrole	120-58-1
118.	Methapyrilene	91-80-5
119.	3-Methylcholanthrene	56-49-5
120	4,4'-Methylenebis (2-chloroaniline)	101-14-4
36	Methyl methanesulfonate	66-27-3
121.	Naphthalene	91-20-3
122	1,4-Naphthoquinone	130-15-4
123	1-Naphthylamine	134-32-7
124.	2-Naphthylamine	91-59-8
125.	p-Nitroaniline	100-01-6
126.	Nitrobenzene	98-95-3
127.	4-Nitrophenol	100-02-7
128.	N-Nitrosodi-n-butylamine	924-16-3
129.	N-Nitrosodiethylamine	55-18-5
130.	N-Nitrosodimethylamine	62-75-9
131	N-Nitrosomethylethylamine	10595-95-6
132.	N-Nitrosomorpholine	59-89-2
133.	N-Nitrosopiperidine	100-75-4
134.	n-Nitrosopyrrolidine	930-55-2
135	5-Nitro-o-toluidine	99-65-8
136.	Pentachlorobenzene	608-93-5
137	Pentachloroethane	76-01-7
138	Pentachloronitrobenzene	82-68-8

Table 1-1 (continued)

BDAT reference no	Parameter	CAS no.
	Semivolatiles (continued)	
139.	Pentachlorophenol	87-86-5
140	Phenacetin	62-44-2
141.	Phenanthrene	85-01-8
142	Phenol	108-95-2
220.	Phthalic anhydride	85-44-9
143	2-Picoline	109-06-8
144.	Pronamide	23950-58-5
145	Pyrene	129-00-0
146	Resorcinol	108-46-3
147.	Safrole	94-59-7
148	1,2,4,5-Tetrachlorobenzene	95-94-3
149.	2,3,4,6-Tetrachlorophenol	58-90-2
150.	1,2,4-Trichlorobenzene	120-82-1
151.	2,4,5-Trichlorophenol	95-95-4
152.	2,4,6-Trichlorophenol	88-06-2
153.	Tris(2,3-dibromopropyl) phosphate	126-72-7
	Metals	
154.	Antimony	7440-36-0
155.	Arsenic	7440-38-2
156.	Barium	7440-39-3
157.	Beryllium	7440-41-7
158.	Cadmium	7440-43-9
159.	Chromium (total)	7440-47-32
221.	Chromium (hexavalent)	-
160	Copper	7440-50-8
161.	Lead	7439-92-1
162	Mercury	7439-97-6
163.	Nickel	7440-02-0
164	Selenium	7782-49-2
165.	Silver	7440-22-4
166	Thallium	7440-28-0
167	Vanadium	7440-62-2
168	Zinc	7440-66-6
	Inorganics	
169	Cyanide	57-12-5
170	Fluoride	16964-48-8
171.	Sulfide	8496-25-8

Table 1-1 (continued)

BDAT reference no	Parameter	CAS no.
	Organochlorine pesticides	
172	Aldrin	309-00-2
173	alpha-BHC	319-84-6
174	beta-BHC	319-85-7
175	delta-BHC	319-86-8
176	gamma-BHC	58-89-9
177	Chlordane	57-74-9
178.	DDD	72-54-8
179.	DDE	72-55-9
180.	DDT	50-29-3
181	Dieldrin	60-57-1
182	Endosulfan I	939-98-8
183.	Endosulfan II	33213-6-5
184	Endrin	72-20-8
185	Endrin aldehyde	7421-93-4
186.	Heptachlor	76-44-8
187.	Heptachlor epoxide	1024-57-3
188.	Isodrin	465-73-6
189.	Kepone	143-50-0
190.	Methoxyclor	72-43-5
191.	Toxaphene	8001-35-2
	Phenoxyacetic acid herbicides	
192	2,4-Dichlorophenoxyacetic acid	94-75-7
193.	Silvex	93-72-1
194.	2,4,5-T	93-76-5
	Organophosphorous insecticides	
195	Disulfoton	298-04-4
196	Famphur	52-85-7
197	Methyl parathion	298-00-0
198.	Parathion	56-38-2
199.	Phorate	298-02-2
	PCBs	
200	Aroclor 1016	12674-11-2
201	Aroclor 1221	11104-28-2
202	Aroclor 1232	11141-16-5

Table 1-1 (continued)

BDAT reference no	Parameter	CAS no.
	PCBs (continued)	
203	Aroclor 1242	53469-21-9
204	Aroclor 1248	12672-29-6
205.	Aroclor 1254	11097-69-1
206.	Aroclor 1260	11096-82-5
	Dioxins and furans	
207.	Hexachlorodibenzo-p-dioxins	-
208.	Hexachlorodibenzofurans	-
209	Pentachlorodibenzo-p-dioxins	-
210	Pentachlorodibenzofurans	-
211.	Tetrachlorodibenzo-p-dioxins	-
212	Tetrachlorodibenzofurans	-
213.	2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6

The initial BDAT constituent list was published in EPA's Generic Quality Assurance Project Plan, March 1987 (EPA/530-SW-87-011). Additional constituents will be added to the BDAT constituent list as additional key constituents are identified for specific waste codes or as new analytical methods are developed for hazardous constituents. For example, since the list was published in March 1987, eighteen additional constituents (hexavalent chromium, xylene (all three isomers), benzal chloride, phthalic anhydride, ethylene oxide, acetone, n-butyl alcohol, 2-ethoxyethanol, ethyl acetate, ethyl benzene, ethyl ether, methanol, methyl isobutyl ketone, 2-nitropropane, 1,1,2-trichloro-1,2,2-trifluoroethane, and cyclohexanone) have been added to the list.

Chemicals are listed in Appendix VIII if they are shown in scientific studies to have toxic, carcinogenic, mutagenic, or teratogenic effects on humans or other life-forms, and they include such substances as those identified by the Agency's Carcinogen Assessment Group as being carcinogenic. Including a constituent in Appendix VIII means that the constituent can be cited as a basis for listing toxic wastes.

Although Appendix VII, Appendix VIII, and the F003 and F005 ignitables provide a comprehensive list of RCRA-regulated hazardous constituents, not all of the constituents can be analyzed in a complex waste matrix. Therefore, constituents that could not be readily analyzed in an unknown waste matrix were not included on the initial BDAT list. As mentioned above, however, the BDAT constituent list is a continuously growing list that does not preclude the addition of new constituents when analytical methods are developed.

There are 5 major reasons that constituents were not included on the BDAT constituent list:

(a) Constituents are unstable. Based on their chemical structure, some constituents will either decompose in water or will ionize. For example, maleic anhydride will form maleic acid when it comes in contact with water and copper cyanide will ionize to form copper and cyanide ions. However, EPA may choose to regulate the decomposition or ionization products.

(b) EPA-approved or verified analytical methods are not available. Many constituents, such as 1,3,5-trinitrobenzene, are not measured adequately or even detected using any of EPA's analytical methods published in SW-846 Third Edition.

(c) The constituent is a member of a chemical group designated in Appendix VIII as not otherwise specified (N.O.S.). Constituents listed as N.O.S., such as chlorinated phenols, are a generic group of some types of chemicals for which a single analytical procedure is not available. The individual members of each such group need to be listed to determine whether the constituents can be analyzed. For each N.O.S. group, all those constituents that can be readily analyzed are included in the BDAT constituents list.

(d) Available analytical procedures are not appropriate for a complex waste matrix. Some compounds, such as auramine, can be analyzed as a pure constituent. However, in the presence of other constituents, the recommended analytical method does not positively identify the constituent. The use of high pressure liquid chromotography (HPLC) presupposes a high expectation of finding the specific constituents of interest. In using this procedure to screen samples, protocols would have to be developed on a case-specific basis to verify the identity of constituents present in the samples. Therefore, HPLC is not an appropriate analytical procedure for complex samples containing unkown constituents.

(e) Standards for analytical instrument calibration are not commercially available. For several constituents, such as benz(c)acridine, commercially available standards of a "reasonably" pure grade are not available. The unavailability of a standard was determined by a review of catalogs from specialty chemical manufacturers.

Two constituents (fluoride and sulfide) are not specifically included in Appendices VII and VIII; however, these compounds are included on the BDAT list as indicator constituents for compounds from Appendices VII and VIII such as hydrogen fluoride and hydrogen sulfide, which ionize in water.

The BDAT constituent list presented in Table 1-1 is divided into the following nine groups:

- Volatile organics
- Semivolatile organics
- Metals
- Other inorganics
- Organochlorine pesticides
- Phenoxyacetic acid herbicides
- Organophosphorous insecticides
- PCBs
- Dioxins and furans

The constituents were placed in these categories based on their chemical properties. The constituents in each group are expected to behave similarily during treatment and are also analyzed, with the exception of the metals and inorganics, by using the same analytical methods.

(2) Constituent Selection Analysis. The constituents that the Agency selects for regulation in each treatability group are, in general, those found in the untreated wastes at treatable concentrations. For certain waste codes, the target list for the untreated waste may have been shortened (relative to analyses performed to test treatment technologies) because of the extreme unlikelihood of the constituent being present.

In selecting constituents for regulation, the first step is to summarize all the constituents that were found in the untreated waste at treatable concentrations. This process involves the use of the statistical analysis of variance (ANOVA) test, described in Section 1.2.6, to determine if constituent reductions were significant. The Agency interprets a significant reduction in concentration as evidence that the technology actually "treats" the waste.

There are some instances where EPA may regulate constituents that are not found in the untreated waste but are detected in the treated residual. This is generally the case where presence of the constituents in the untreated waste interferes with the quantification of the constituent of concern. In such instances, the detection levels of the constituent are relatively high, resulting in a finding of "not detected" when, in fact, the constituent is present in the waste.

After determining which of the constituents in the untreated waste are present at treatable concentrations, EPA develops a list of potential constituents for regulation. The Agency then reviews this list to determine if any of these constituents can be excluded from regulation because they would be controlled by regulation of other constituents in the list.

EPA performs this indicator analysis for two reasons: (1) it reduces the analytical cost burdens on the treater and (2) it facilitates implementation of the compliance and enforcement program. EPA's rationale for selection of regulated constituents for this waste code is presented in Section 5 of this background document.

(3) Calculation of Standards. The final step in the calculation of the BDAT treatment standard is the multiplication of the average treatment value by a factor referred to by the Agency as the variability factor. This calculation takes into account that even well-designed and well-operated treatment systems will experience some fluctuations in performance. EPA expects that fluctuations will result from inherent mechanical limitations in treatment control systems, collection of treated samples, and analysis of these samples. All of the above fluctuations can be expected to occur at well-designed and well-operated treatment facilities. Therefore, setting treatment standards utilizing a variability factor should be viewed not as a relaxing of 3004(m) requirements, but rather as a function of the normal variability of the treatment processes. A treatment facility will have to be designed to meet the mean achievable treatment performance level to ensure that the performance levels remain within the limits of the treatment standard.

The Agency calculates a variability factor for each constituent of concern within a waste treatability group using the statistical calculation presented in Appendix A. The equation for calculating the variability factor is the same as that used by EPA for the development of numerous regulations in the Effluent Guidelines Program under the Clean Water Act. The variability factor establishes the instantaneous maximum based on the 99th percentile value.

There is an additional step in the calculation of the treatment standards in those instances where the ANOVA analysis shows that more

than one technology achieves a level of performance that represents BDAT. In such instances, the BDAT treatment standard is calculated by first averaging the mean performance value for each technology for each constituent of concern and then multiplying that value by the highest variability factor among the technologies considered. This procedure ensures that all the BDAT technologies used as the basis for the standards will achieve full compliance.

1.2.5 Compliance with Performance Standards

All the treatment standards reflect performance achieved by the Best Demonstrated Available Technology (BDAT). As such, compliance with these standards only requires that the treatment level be achieved prior to land disposal. It does not require the use of any particular treatment technology. While dilution of the waste as a means to comply with the standard is prohibited, wastes that are generated in such a way as to naturally meet the standard can be land disposed without treatment. With the exception of treatment standards that prohibit land disposal, all treatment standards proposed are expressed as a concentration level.

EPA has used both total constituent concentration and TCLP analyses of the treated waste as a measure of technology performance. EPA's rationale for when each of these analytical tests is used is explained in the following discussion.

For all organic constituents, EPA is basing the treatment standards on the total constituent concentration found in the treated waste. EPA based its decision on the fact that technologies exist to destroy the

various organics compounds. Accordingly, the best measure of performance would be the extent to which the various organic compounds have been destroyed or the total amount of constituent remaining after treatment. (NOTE: EPA's land disposal restrictions for solvent waste codes F001-F005 (51 FR 40572) uses the TCLP value as a measure of performance. At the time that EPA promulgated the treatment standards for F001-F005, useful data were not available on total constituent concentrations in treated residuals and, as a result, the TCLP data were considered to be the best measure of performance.)

For all metal constituents, EPA is using both total constituent concentration and/or the TCLP as the basis for treatment standards. The total constituent concentration is being used when the technology basis includes a metal recovery operation. The underlying principle of metal recovery is the reduction of the amount of metal in a waste by separating the metal for recovery; therefore, total constituent concentration in the treated residual is an important measure of performance for this technology. Additionally, EPA also believes that it is important that any remaining metal in a treated residual waste not be in a state that is easily leachable; accordingly, EPA is also using the TCLP as a measure of performance. It is important to note that for wastes for which treatment standards are based on a metal recovery process, the facility has to comply with both the total constituent concentration and the TCLP prior to land disposal.

In cases where treatment standards for metals are not based on recovery techniques but rather on stabilization, EPA is using only the TCLP as a measure of performance. The Agency's rationale is that stabilization is not meant to reduce the concentration of metal in a waste but only to chemically minimize the ability of the metal to leach.

1.2.6 Identification of BDAT

(1) Screening of Treatment Data. This section explains how the Agency determines which of the treatment technologies represent treatment by BDAT. The first activity is to screen the treatment performance data from each of the demonstrated and available technologies according to the following criteria:

(a) Design and operating data associated with the treatment data must reflect a well-designed, well-operated system for each treatment data point. (The specific design and operating parameters for each demonstrated technology for this waste code are discussed in Section 3.2 of this document.)

(b) Sufficient QA/QC data must be available to determine the true values of the data from the treated waste. This screening criterion involves adjustment of treated data to take into account that the type value may be different from the measured value. This discrepancy generally is caused by other constituents in the waste that can mask results or otherwise interfere with the analysis of the constituent of concern.

(c) The measure of performance must be consistent with EPA's approach to evaluating treatment by type of constituents (e.g., total concentration data for organics, and total concentration and TCLP for metals in the leachate from the residual).

In the absence of data needed to perform the screening analysis, EPA will make decisions on a case-by-case basis of whether to include the data. The factors included in this case-by-case analysis will be the

actual treatment levels achieved, the availability of the treatment data and their completeness (with respect to the above criteria), and EPA's assessment of whether the untreated waste represents the waste code of concern. EPA's application of these screening criteria for this waste code are provided in Section 4 of this background document.

(2) Comparison of Treatment Data. In cases in which EPA has treatment data from more than one technology following the screening activity, EPA uses the statistical method known as analysis of variance (ANOVA) to determine if one technology performs significantly better. This statistical method (summarized in Appendix A) provides a measure of the differences between two data sets. If EPA finds that one technology performs significantly better (i.e., the data sets are not homogeneous), BDAT treatment standards are the level of performance achieved by the best technology multiplied by the corresponding variability factor for each regulated constituent.

If the differences in the data sets are not statistically significant, the data sets are said to be homogeneous. Specifically, EPA uses the analysis of variance to determine whether BDAT represents a level of performance achieved by only one technology or represents a level of performance achieved by more than one (or all) of the technologies. If the Agency finds that the levels of performance for one or more technologies are not statistically different, EPA averages the performance values achieved by each technology and then multiplies this value by the largest variability factor associated with any of the

acceptable technologies. A detailed discussion of the treatment selection method and an example of how EPA chooses BDAT from multiple treatment systems is provided in Section A-1.

(3) Quality Assurance/Quality Control. This section presents the principal quality assurance/quality control (QA/QC) procedures employed in screening and adjusting the data to be used in the calculation of treatment standards. Additional QA/QC procedures used in collecting and screening data for the BDAT program are presented in EPA's Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT") (EPA/530-SW-87-001, March 1987).

To calculate the treatment standards for the Land Disposal Restriction Rules, it is first necessary to determine the recovery value for each constituent (the amount of constituent recovered after spiking, which is the addition of a known amount of the constituent, minus the initial concentration in the samples divided by the amount added) for a spike of the treated residual. Once the recovery value is determined, the following procedures are used to select the appropriate percent recovery value to adjust the analytical data:

(a) If duplicate spike recovery values are available for the constituent of interest, the data are adjusted by the lowest available percent recovery value (i.e., the value that will yield the most conservative estimate of treatment achieved). However, if a spike recovery value of less than 20 percent is reported for a specific constituent, the data are not used to set treatment standards because the Agency does not have sufficient confidence in the reported value to set a national standard.

(b) If data are not available for a specific constituent but are available for an isomer, then the spike recovery data are transferred from the isomer and the data are adjusted using the percent recovery selected according to the procedure described in (a) above.

(c) If data are not available for a specific constituent but are available for a similar class of constituents (e.g., volatile organics, acid-extractable semivolatiles), then spike recovery data available for this class of constituents are transferred. All spike recovery values greater than or equal to 20 percent for a spiked sample are averaged and the constituent concentration is adjusted by the average recovery value. If spiked recovery data are available for more than one sample, the average is calculated for each sample and the data are adjusted by the lowest average value.

(d) If matrix spike recovery data are not available for a set of data to be used to calculate treatment standards, then matrix spike recovery data are transferred from a waste that the Agency believes is a similar matrix (e.g., if the data are for an ash from incineration, then data from other incinerator ashes could be used). While EPA recognizes that transfer of matrix spike recovery data from a similar waste is not an exact analysis, this is considered the best approach for adjusting the data to account for the fact that most analyses do not result in extraction of 100 percent of the constituent. In assessing the recovery data to be transferred, the procedures outlined in (a), (b), and (c) above are followed.

The analytical procedures employed to generate the data used to calculate the treatment standards are listed in Appendix B of this document. In cases where alternatives or equivalent procedures and/or equipment are allowed in EPA's SW-846, Third Edition (November 1986) methods, the specific procedures and equipment used are also documented in this Appendix. In addition, any deviations from the SW-846, Third Edition, methods used to analyze the specific waste matrices are documented. It is important to note that the Agency will use the methods and procedures delineated in Appendix B to enforce the treatment

standards presented in Section 6 of this document. Accordingly, facilities should use these procedures in assessing the performance of their treatment systems.

1.2.7 BDAT Treatment Standards for "Derived-From" and "Mixed" Wastes

(1) Wastes from Treatment Trains Generating Multiple Residues. In a number of instances, the proposed BDAT consists of a series of operations each of which generates a waste residue. For example, the proposed BDAT for a certain waste code is based on solvent extraction, steam stripping, and activated carbon adsorption. Each of these treatment steps generates a waste requiring treatment -- a solvent-containing stream from solvent extraction, a stripper overhead, and spent activated carbon. Treatment of these wastes may generate further residues; for instance, spent activated carbon (if not regenerated) could be incinerated, generating an ash and possibly a scrubber water waste. Ultimately, additional wastes are generated that may require land disposal. With respect to these wastes, the Agency wishes to emphasize the following points:

(a) All of the residues from treating the original listed wastes are likewise considered to be the listed waste by virtue of the derived-from rule contained in 40 CFR Part 261.3(c)(2). (This point is discussed more fully in (2) below.) Consequently, all of the wastes generated in the course of treatment would be prohibited from land disposal unless they satisfy the treatment standard or meet one of the exceptions to the prohibition.

(b) The Agency's proposed treatment standards generally contain a concentration level for wastewaters and a concentration level for nonwastewaters. The treatment standards apply to all of the wastes generated in treating the original prohibited waste. Thus, all solids generated from treating these wastes would have

to meet the treatment standard for nonwastewaters. All derived-from wastes meeting the Agency definition of wastewater (less than 1 percent TOC and less than 1 percent total filterable solids) would have to meet the treatment standard for wastewaters. EPA wishes to make clear that this approach is not meant to allow partial treatment in order to comply with the applicable standard.

(c) The Agency has not performed tests, in all cases, on every waste that can result from every part of the treatment train. However, the Agency's treatment standards are based on treatment of the most concentrated form of the waste. Consequently, the Agency believes that the less concentrated wastes generated in the course of treatment will also be able to be treated to meet this value.

(2) Mixtures and Other Derived-From Residues. There is a further question as to the applicability of the BDAT treatment standards to residues generated not from treating the waste (as discussed above), but from other types of management. Examples are contaminated soil or leachate that is derived from managing the waste. In these cases, the mixture is still deemed to be the listed waste, either because of the derived-from rule (40 CFR Part 261.3(c)(2)(i)) or the mixture rule (40 CFR Part 261.3(a)(2)(iii) and (iv) or because the listed waste is contained in the matrix (see, for example, 40 CFR Part 261.33(d)). The prohibition for the particular listed waste consequently applies to this type of waste.

The Agency believes that the majority of these types of residues can meet the treatment standards for the underlying listed wastes (with the possible exception of contaminated soil and debris for which the Agency is currently investigating whether it is appropriate to establish a separate treatability subcategorization). For the most part, these

residues will be less concentrated than the original listed waste. The Agency's treatment standards also make a generous allowance for process variability by assuming that all treatability values used to establish the standard are lognormally distributed. The waste also might be amenable to a relatively nonvariable form of treatment technology such as incineration. Finally, and perhaps most important, the rules contain a treatability variance that allows a petitioner to demonstrate that its waste cannot be treated to the level specified in the rule (40 CFR Part 268.44(a). This provision provides a safety valve that allows persons with unusual waste matrices to demonstrate the appropriateness of a different standard. The Agency, to date, has not received any petitions under this provision (for example, for residues contaminated with a prohibited solvent waste), indicating, in the Agency's view, that the existing standards are generally achievable.

(3) Residues from Managing Listed Wastes or that Contain Listed Wastes. The Agency has been asked if and when residues from managing hazardous wastes, such as leachate and contaminated ground water, become subject to the land disposal prohibitions. Although the Agency believes this question to be settled by existing rules and interpretative statements, to avoid any possible confusion the Agency will address the question again.

Residues from managing First Third wastes, listed California List wastes, and spent solvent and dioxin wastes are all considered to be subject to the prohibitions for the underlying hazardous waste. Residues

from managing California List wastes likewise are subject to the California List prohibitions when the residues themselves exhibit a characteristic of hazardous waste. This determination stems directly from the derived-from rule in 40 CFR Part 261.3(c)(2) or in some cases from the fact that the waste is mixed with or otherwise contains the listed waste. The underlying principle stated in all of these provisions is that listed wastes remain listed until delisted.

The Agency's historic practice in processing delisting petitions addressing mixing residuals has been to consider them to be the listed waste and to require that delisting petitioners address all constituents for which the derived-from waste (or other mixed waste) was listed. The language in 40 CFR Part 260.22(b) states that mixtures or derived-from residues can be delisted provided a delisting petitioner makes a demonstration identical to that which a delisting petitioner would make for the underlying waste. These residues consequently are treated as the underlying listed waste for delisting purposes. The statute likewise takes this position, indicating that soil and debris that are contaminated with listed spent solvents or dioxin wastes are subject to the prohibition for these wastes even though these wastes are not the originally generated waste, but rather are a residual from management (RCRA section 3004(e)(3)). It is EPA's view that all such residues are covered by the existing prohibitions and treatment standards for the listed hazardous waste that these residues contain and from which they are derived.

1.2.8 Transfer of Treatment Standards

EPA is proposing some treatment standards that are not based on testing of the treatment technology of the specific waste subject to the treatment standard. Instead, the Agency has determined that the constituents present in the subject waste can be treated to the same performance levels as those observed in other wastes for which EPA has previously developed treatment data. EPA believes that transferring treatment performance for use in establishing treatment standards for untested wastes is valid technically in cases where the untested wastes are generated from similar industries, similar processing steps, or have similar waste characteristics affecting performance and treatment selection. Transfer of treatment standards to similar wastes or wastes from similar processing steps requires little formal analysis. However, in the case where only the industry is similar, EPA more closely examines the waste characteristics prior to concluding that the untested waste constituents can be treated to levels associated with tested wastes.

EPA undertakes a two-step analysis when determining whether wastes generated by different processes within a single industry can be treated to the same level of performance. First, EPA reviews the available waste characteristic data to identify those parameters that are expected to affect treatment selection. EPA has identified some of the most important constituents and other parameters needed to select the treatment technology appropriate for a given waste. A detailed discussion of each analysis, including how each parameter was selected for each waste, can be found in the background document for each waste.

Second, when an individual analysis suggests that an untested waste can be treated with the same technology as a waste for which treatment performance data are already available, EPA analyzes a more detailed list of constituents that represent some of the most important waste characteristics that the Agency believes will affect the performance of the technology. By examining and comparing these characteristics, the Agency determines whether the untested wastes will achieve the same level of treatment as the tested waste. Where the Agency determines that the untested waste is easier to treat than the tested waste, the treatment standards can be transferred. A detailed discussion of this transfer process for each waste can be found in later sections of this document.

1.3 Variance from the BDAT Treatment Standard

The Agency recognizes that there may exist unique wastes that cannot be treated to the level specified as the treatment standard. In such a case, a generator or owner/operator may submit a petition to the Administrator requesting a variance from the treatment standard. A particular waste may be significantly different from the wastes considered in establishing treatability groups because the waste contains a more complex matrix that makes it more difficult to treat. For example, complex mixtures may be formed when a restricted waste is mixed with other waste streams by spills or other forms of inadvertent mixing. As a result, the treatability of the restricted waste may be altered such that it cannot meet the applicable treatment standard.

Variance petitions must demonstrate that the treatment standard established for a given waste cannot be met. This demonstration can be

made by showing that attempts to treat the waste by available technologies were not successful or by performing appropriate analyses of the waste, including waste characteristics affecting performance, which demonstrate that the waste cannot be treated to the specified levels. Variances will not be granted based solely on a showing that adequate BDAT treatment capacity is unavailable. (Such demonstrations can be made according to the provisions in Part 268.5 of RCRA for case-by-case extensions of the effective date.) The Agency will consider granting generic petitions provided that representative data are submitted to support a variance for each facility covered by the petition.

Petitioners should submit at least one copy to:

The Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

An additional copy marked "Treatability Variance" should be submitted to:

Chief, Waste Treatment Branch
Office of Solid Waste (WH-565)
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

Petitions containing confidential information should be sent with only the inner envelope marked "Treatability Variance" and "Confidential Business Information" and with the contents marked in accordance with the requirements of 40 CFR Part 2 (41 FR 36902, September 1, 1976, amended by 43 FR 4000).

The petition should contain the following information:

(1) The petitioner's name and address.

(2) A statement of the petitioner's interest in the proposed action.

(3) The name, address, and EPA identification number of the facility generating the waste, and the name and telephone number of the plant contact.

(4) The process(es) and feed materials generating the waste and an assessment of whether such process(es) or feed materials may produce a waste that is not covered by the demonstration.

(5) A description of the waste sufficient for comparison with the waste considered by the Agency in developing BDAT, and an estimate of the average and maximum monthly and annual quantities of waste covered by the demonstration. (Note: The petitioner should consult the appropriate BDAT background document for determining the characteristics of the wastes considered in developing treatment standards.)

(6) If the waste has been treated, a description of the system used for treating the waste, including the process design and operating conditions. The petition should include the reasons the treatment standards are not achievable and/or why the petitioner believes the standards are based on inappropriate technology for treating the waste. (Note: The petitioner should refer to the BDAT background document as guidance for determining the design and operating parameters that the Agency used in developing treatment standards.)

(7) A description of the alternative treatment systems examined by the petitioner (if any); a description of the treatment system deemed appropriate by the petitioner for the waste in question; and, as appropriate, the concentrations in the treatment residual or extract of the treatment residual (i.e., using the TCLP where appropriate for stabilized metals) that can be achieved by applying such treatment to the waste.

(8) A description of those parameters affecting treatment selection and waste characteristics that affect performance, including results of all analyses. (See Section 3.0 for a discussion of waste characteristics affecting performance that the Agency has identified for the technology representing BDAT.)

(9) The dates of the sampling and testing.

(10) A description of the methodologies and equipment used to obtain representative samples.

(11) A description of the sample handling and preparation techniques, including techniques used for extraction, containerization, and preservation of the samples.

(12) A description of analytical procedures used including QA/QC methods.

After receiving a petition for a variance, the Administrator may request any additional information or waste samples that may be required to evaluate and process the petition. Additionally, all petitioners must certify that the information provided to the Agency is accurate under 40 CFR Part 268.4(b).

In determining whether a variance will be granted, the Agency will first look at the design and operation of the treatment system being used. If EPA determines that the technology and operation are consistent with BDAT, the Agency will evaluate the waste to determine if the waste matrix and/or physical parameters are such that the BDAT treatment standards reflect treatment of this waste. Essentially, this latter analysis will concern the parameters affecting treatment selection and waste characteristics affecting performance parameters.

In cases where BDAT is based on more than one technology, the petitioner will need to demonstrate that the treatment standard cannot be met using any of the technologies, or that none of the technologies are appropriate for treatment of the waste. After the Agency has made a determination on the petition, the Agency's findings will be published in the Federal Register, followed by a 30-day period for public comment.

After review of the public comments, EPA will publish its final determination in the Federal Register as an amendment to the treatment standards in 40 CFR Part 268, Subpart D.

2. INDUSTRY AFFECTED AND WASTE CHARACTERIZATION

The previous section discussed the BDAT program and the methodology used by the Agency to develop treatment standards. The purpose of this section is to describe the industry affected by the land disposal restrictions for K061, the process generating the waste, and the available waste characterization data.

According to 40 CFR Part 261.32 (hazardous wastes from specific sources), the waste identified as K061 is specifically generated by the iron and steel industry and is defined as: emission control dust/sludge from the primary production of steel in electric furnaces. The waste is listed for lead, chromium, and cadmium.

2.1 Industry Affected and Process Description

The four digit Standard Industrial Classification (SIC) code most often reported for the iron and steel industry is 3312. Information compiled from trade associations provide a geographic distribution of the number of electric furnace steel producers across the United States. Table 2-1 lists the number of facilities by State. Table 2-2 summarizes the number of facilities for each EPA Region. Figure 2-1 illustrates these data geographically on a map of the United States.

K061 is generated during the primary production of steel in electric furnaces. The primary production of steel in electric furnaces generates particulate emissions which contain hazardous constituents present in the raw materials. The particulates, which are primarily comprised of iron, BDAT list metals, and other inorganics, are removed from off gases by

Table 2-1 Number of Producers of Steel in Electric Furnaces by State

EPA Region	State	Producers*
I	Connecticut	1
II	New Jersey	2
II	New York	4
III	Delaware	1
III	Maryland	2
III	Pennsylvania	24
IV	Alabama	2
IV	Florida	3
IV	Georgia	2
IV	Kentucky	3
IV	Mississippi	1
IV	North Carolina	1
IV	South Carolina	2
IV	Tennessee	1
V	Illinois	11
V	Indiana	3
V	Michigan	4
V	Minnesota	1
V	Ohio	6
VI	Louisiana	1
VI	Texas	8
VII	Montana	1
VII	Nebraska	1
VIII	Colorado	1
VIII	Utah	1
IX	Arizona	1
IX	California	3
X	Washington	3

Reference: Directory of Iron and Steel Works of the U.S. and Canada, American Iron and Steel Institute, 1984.

*These data are based on 1984 survey by the American Iron and Steel Institute Of the above listed 94 plants, it has been estimated that 10%, or 9, have closed. The estimate of 85 plants reflects this information.

Table 2-2 Number of Producers of Steel in Electric Furnaces by EPA Region

EPA Region	Producers*
I	1
II	6
III	27
IV	15
V	25
VI	9
VII	2
VIII	2
IX	4
X	3

Reference: Directory of Iron and Steel Works of the U.S. and Canada, American Iron and Steel Institute, 1984

*These data are based on 1984 survey by the American Iron and Steel Institute. Of the above listed 94 plants, it has been estimated that 10%, or 9, have closed. The estimate of 85 plants reflects this information.

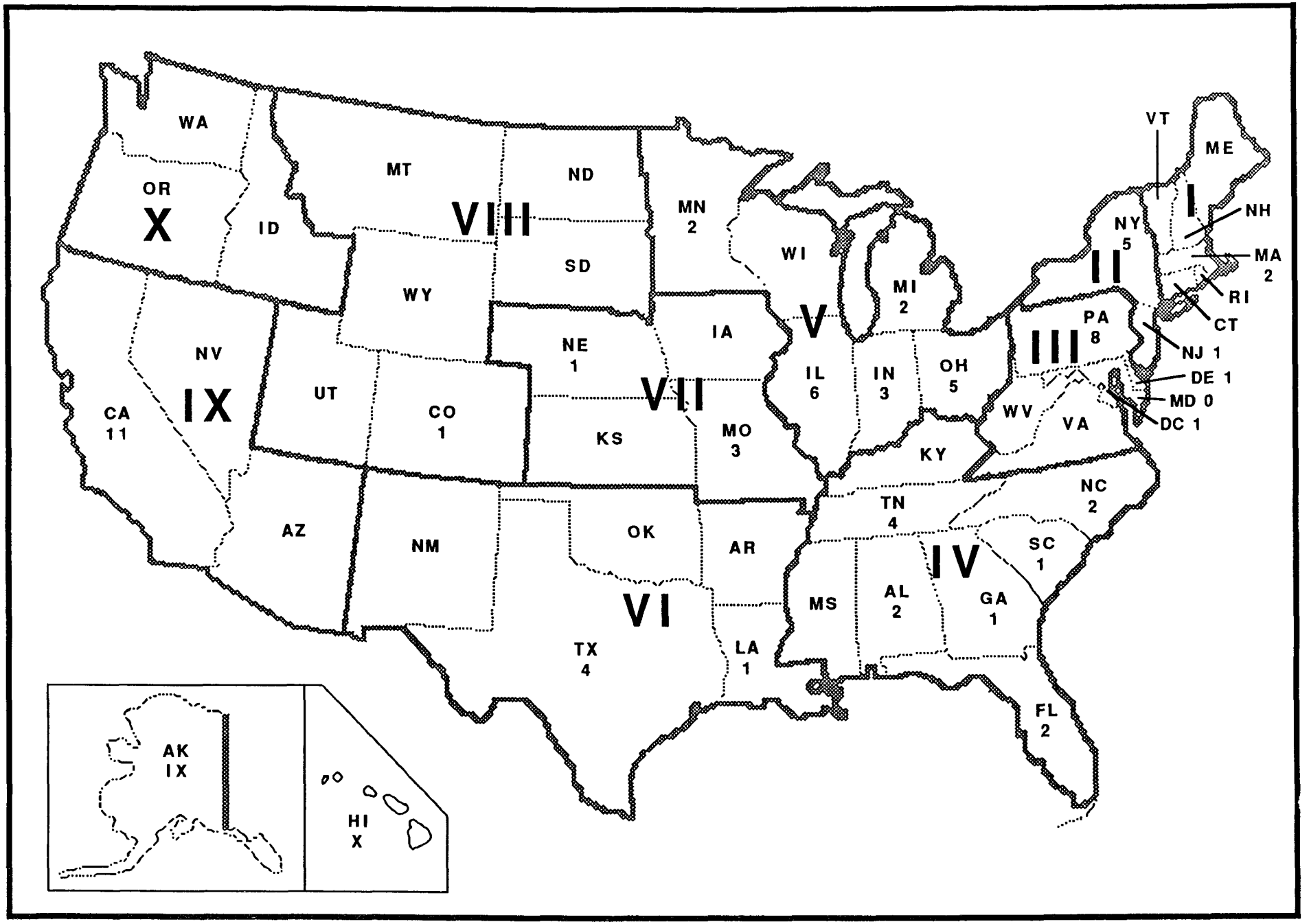

FIGURE 2-1. FACILITIES PRODUCING STEEL IN ELECTRIC FURNACES BY STATE AND EPA REGION*

* These data based on 1984 survey by the American Iron and Steel Institute. Of the above listed 94 plants, it has been estimated that 10%, or 9, have closed. The estimate of 85 plants reflect this information.

baghouses,venturi scrubbers, or electrostatic precipitators. The process that generates K061 is illustrated in Figure 2-2.

The raw materials used in primary steel production in electric furnaces include steel scrap, alloying elements, cold iron, and fluxes such as limestone and/or fluorspar. The feed materials are charged into a refractory-lined furnace and melted by the electric current surging through the steel between electrodes. The high temperature arc-zone (about 3,000°F) melts the scrap in an oxidizing atmosphere. Particulate emissions containing iron, zinc, lead, cadmium, chromium, and other components are liberated in the fume from the furnace during the melting of scrap material, injection of additives, refining periods, and tapping of furnaces.

The formation of particulates occurs as a result of the oxidation, condensation, and deposition of material from the vapor phase onto fugitive dust. Therefore, the particulates formed consist of numerous constituents. The dust collected by baghouses, venturi scrubbers, or electrostatic precipitators is the listed waste K061.

2.2 Waste Characterization

This section includes all waste characterization data available to the Agency for K061. An estimate of the major constituents which comprise the waste and their approximate concentrations is presented in Table 2-3. The percent concentration of each major constituent in the waste was determined by best estimates based on chemical analyses. (Analytical results upon which the estimate is based are reported in

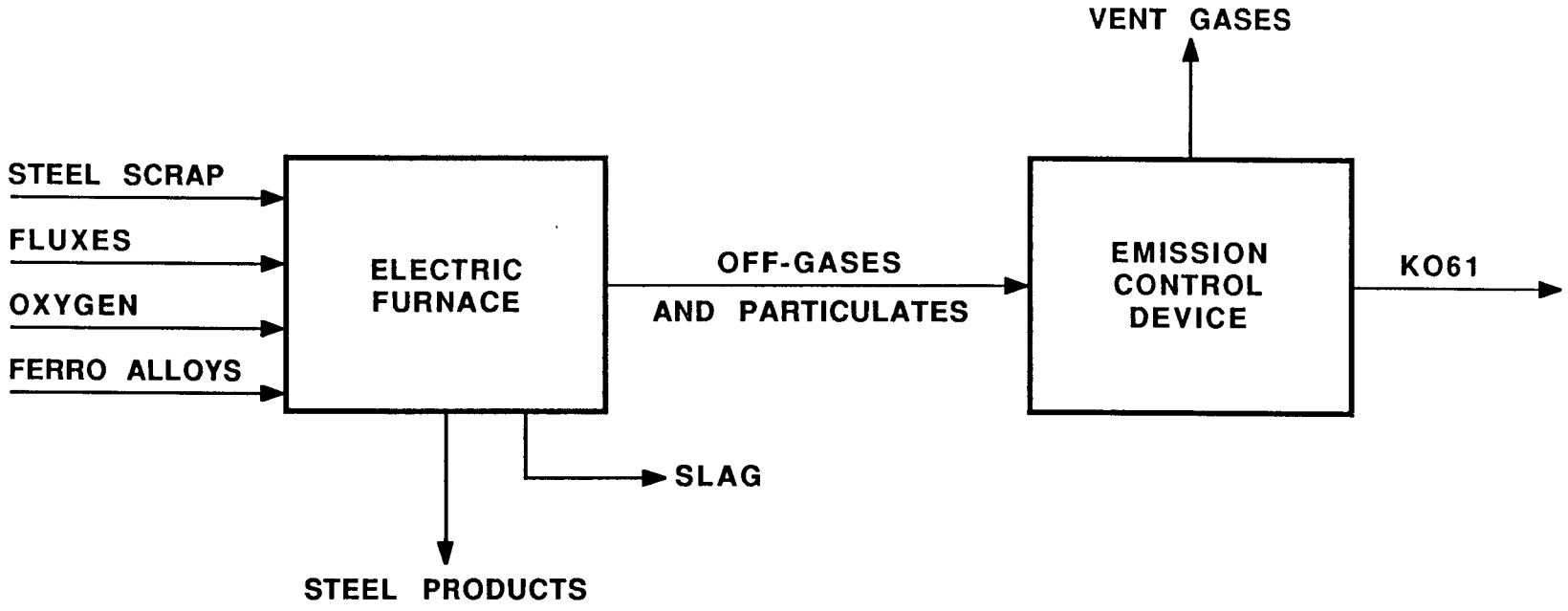

FIGURE 2-2: STEEL PRODUCTION IN ELECTRIC FURNACES

Table 2-3 Major Constituent Composition*

Untreated K061 Waste

Major Constituents	Concentration (%)
Iron	26
Oxygen (in metal oxides)	18
Zinc	16
Water	12
Calcium	7
Other elements (C,N,H)	4
Fluorides	3
Manganese	3
Lead	2
Magnesium	2
Alkali Metals (Na, K)	2
Silica	2
Chlorides	2
Other BDAT metals (Cd,Cr,Cu,Ni,Ba,Hg,As,etc.)	<0.5
TOTAL	100%

* Approximate percent concentrations presented here were developed based on EPA's review of chemical analyses.

reference numbers 20 and 21.) The Agency has obtained waste composition data from its own testing programs and from numerous industry sources. The ranges of BDAT list constituents present in these wastes and other available data are presented in Table 2-4.

Table 2-4 represents waste characterization data for K061 wastes collected from 21 sources. The data presented display the wide variation in concentrations of BDAT list metals found in K061 wastes from different generators. The BDAT list metals present in the greatest concentrations include zinc, lead, cadmium, and chromium, however, their concentrations vary widely from sample to sample. In some cases, the concentrations of some metals may vary by greater than a factor of 10, as is the case for chromium and nickel. The wide variations for chromium and nickel in K061 may be attributed to wastes generated from stainless steel production, which contains higher concentrations of these metals than carbon steels. Overall, the composition of the emission control dust varies depending on the grade of steel produced and the scrap material used.

Table 2-4 BDAT Constituent Composition and Other Data

		Untreated K061 Waste Total Concentration (ppm)						
BDAT Constituent	Source of Data	(a)	(b)	(c)	(d)	(e)	(f)	(g)
Antimony		52-89	294	-	-	-	-	-
Arsenic		42-127	36	-	-	-	-	-
Barium		164-204	238	-	-	-	-	-
Beryllium		<0.5-1.5	0.15	-	-	-	-	-
Cadmium		290-857	481	280	-	-	-	1,600
Chromium		803-1,190	1,370	3,800	1,380	2,690	-	102,000
Copper		1,460-2,640	2,240	-	-	-	1,200	-
Lead		14,900-21,900	20,300	15,000	24,220	7,900	1,400	11,000
Mercury		1.0-2.0	3.8	-	-	-	-	-
Nickel		184-449	243	700	-	-	5,900	21,000
Selenium		5 2-20	<5 0	-	-	-	-	-
Silver		23-44	59	-	-	-	-	-
Thallium		0.75-2.7	<1.0	-	-	-	-	-
Vanadium		24-37	25	-	-	-	-	-
Zinc		129,000-155,000	244,000	154,000	-	-	3,900	10,000
Water (%)		12%	-	-	-	-	-	-
Total Organic Carbon		<1%	-	-	-	-	-	-

- = No data

(a) Reference 20 - Onsite Engineering Report for Horsehead Resource Development Co. for K061
(b) Reference 21 - Onsite Engineering Report for Waterways Experiment Station for K061
(c) Reference 6 - U.S Department of Commerce, Characterization, Recovery and Recycling of EAF Dust
(d) Reference 18 - USEPA - RCRA Background Listing Document
(e) Reference 18 - USEPA - RCRA Background Listing Document
(f) Reference 18 - USEPA - RCRA Background Listing Document
(g) Reference 6 - U.S. Department of Commerce, Charaterization, Recovery and Recycling of EAF Dust

Table 2-4 BDAT Constituent Composition and Other Data

	Untreated K061 Waste Total Concentration (ppm)						
BDAT Constituent Source of Data:	(h)	(i)	(j)	(k)	(l)	(m)	(n)
Antimony	-	-	-	-	5.03	-	-
Arsenic	470	-	-	10.2	58.7	-	-
Barium	-	-	-	61.4	205	-	41.9
Beryllium	-	-	-	-	8.08	-	-
Cadmium	1,000	-	1.35	293	1,053	682	13.1
Chromium	25,900	1,380	<0.05	848	1,053	1,029	354
Copper	-	-	-	742	-	-	-
Lead	14,600	24,200	1.29	8,967	40,275	15,875	1,495
Mercury	-	-	-	0.059	15.1	-	0.038
Nickel	-	246	-	137	152.3	-	-
Selenium	600	-	-	1.03	590	-	0.068
Silver	-	-	-	14.5	39.5	-	-
Thallium	-	-	-	-	<10	-	-
Vanadium	-	-	-	-	46.5	-	-
Zinc	-	95,710	-	71,333	-	-	-

- = No data

(h) Reference 4 - U.S Bureau of Mines, Characterization of Steelmaking Dusts from Electric Furnaces
(i) Reference 5 - Calspan Corporation, Metal and Refining Industry
(j) Reference 9 - Harrison Steel Casting, Delisting Petition
(k) Reference 10 - U.S. Steel, Delisting Petition
(l) Reference 11 - Stablex Corp, Delisting Petition
(m) Reference 12 - Marathon Steel, Delisting Petition
(n) Reference 13 - McLouth Steel, Delisting Petition

Table 2-4 BDAT Constituent Composition and Other Data

	Untreated K061 Waste Total Concentration (ppm)						
BDAT Constituent Source of data:	(o)	(p)	(q)	(r)	(s)	(t)	(u)
Antimony	-	-	-	50-150	-	BDL	-
Arsenic	46.7	40	-	<100-400	-	140-260	-
Barium	-	400	-	-	-	20-37	-
Beryllium	-	-	-	-	-	BDL	-
Cadmium	370	600	100-600	200-900	600	60-1,100	1,000
Chromium	426.6	1,100	60,000-100,000	400-5,000	3,900	80-15,000	8,000
Copper	-	-	600-3,000	1,500-2,000	-	490-6,400	-
Lead	11,133	38,000	6,000-14,000	24,000-50,000	4,500	7,300-25,000	30,000
Mercury	-	2	0.7-16	7-41	-	BDL	-
Nickel	-	200	15,000-22,000	1,000-3,000	-	30-16,000	-
Selenium	-	<10	-	-	-	BDL	-
Silver	-	<50	-	-	-	BDL-70	-
Thallium	-	-	-	-	-	-	-
Vanadium	-	-	-	-	-	320-4,800	-
Zinc	186,000	167,000	22,000-53,000	150,000-320,000	188,000	33,000-257,000	220,000

- = No data
BDL = Below the Detection Limit.

(o) Reference 14 - Raritan River Steel, Delisting Petition
(p) Reference 15 - Bethlehem Steel, Delisting Petition
(q) Reference 31 - SKF Plasmadust
(r) Reference 31 - SKF Plasmadust
(s) Reference 33 - Sumitomo Molten Slag
(t) Reference 19 - EPA/OSW Relisting Analyses of EAF Steel
(u) Reference 32 - St. Joe Flame Reactor

3. APPLICABLE/DEMONSTRATED TREATMENT TECHNOLOGIES

This section describes the applicable treatment technologies and performance data for K061. The Agency identified applicable treatment technologies based on available waste composition data, contacts with industry, and from technical publications. The technologies considered to be applicable are those that treat toxic metals by reducing their concentration and/or their leachability. Included in this section are discussions of those applicable treatment technologies that have been demonstrated on a commercial basis. Treatment performance data collected by the Agency for these technologies also are presented.

3.1 Applicable Treatment Technologies

In the previous section there was a discussion of the industries generating K061 and the untreated waste composition. The chemical composition of K061 most directly affects the technology applicable to the waste. As shown in Section 2, K061 waste primarily contains high concentrations of BDAT list metals and other inorganic constituents. There are BDAT list organic compounds present, but these compounds are not found at concentrations for which there is a demonstrated technology capable of providing significant changes in the toxicity or mobility of the waste. Other waste characteristics that may affect the treatment technologies applicable to K061 are filterable solids concentration.

Therefore, the treatment technologies that the Agency has identified as being applicable to K061 are designed to treat BDAT list metal constituents in high filterable solids matrices. These technologies

reduce the concentration of BDAT list metals present in the treated residual and/or result in a treated residual with low leachability of BDAT list metals. The selection of the treatment technologies applicable for treating BDAT list metals in K061 waste is based on current technical publications, available waste composition data, and information submitted by industry.

Initial data gathering on the generation/treatment of K061 waste consisted of: telephone contacts to the American Iron and Steel Institute (AISI), identification of generators from EPA's Hazardous Waste Data Management System (HWDMS), contacts with EPA's Office of Solid Waste Relisting Program, and compilation of available technical publications on electric furnace steel production and K061 waste generation/treatment.

The Agency identified several variations on the following treatment technologies as being applicable for K061 waste: direct and indirect recycle, high temperature metals recovery, hydrometallurgical extraction (leaching), and stabilization. These technologies provide varying degrees of treatment to BDAT list metal constituents. Recycling of K061 directly back into the electric furnace where it was originally produced facilitates the recovery of the metals for steel making while reducing or eliminating the material to be land disposed. High temperature metals recovery is used to recover metals from wastes for reuse and reduces the concentration, leachability, and volume of hazardous waste to be land disposed. Leaching is also used to remove certain metals from wastes based on relative solubilities of the metal compounds. Stabilization is

used to reduce the leachability of metals from the material to be land disposed.

3.2 Demonstrated Treatment Technologies

This section describes the Agency's methodology for identifying the demonstrated treatment technologies for K061. In addition, performance data collected for these technologies that demonstrate their relative effectiveness in treating BDAT list metal constituents are presented.

In order to determine the demonstrated technologies for K061, a list of facilities that may utilize these technologies onsite as an alternative to land disposal was compiled. This list was compiled from the information sources listed previously, and included telephone contacts to several K061 generators and commerical treatment facilities. The available information indicate that there is no onsite treatment of K061 and that most companies land dispose the waste. Of the applicable technologies, recycle (direct/indirect), high temperature metals recovery, hydrometallurgical extraction (leaching), and stabilization, EPA has identified only two of these as being demonstrated on K061 waste: high temperature metals recovery and stabilization. EPA has not been able to identify any instances where leaching and recycling have been successfully applied to K061 or a similar waste on a commercial scale. Additional descriptions of recycling technologies that have been attempted and other potentially applicable technologies is provided in Section 3.3.

The Agency is aware of at least four facilities in the United States and ten in foreign countries that use high temperature metals recovery to treat emission control dust/sludge from primary steel production in electric furnaces. As a result, five different systems of high temperature metals recovery have been identified as being demonstrated for K061: the rotary kiln process, rotary hearth/electric furnace, the plasma arc reactor, molten slag reactor, and flame reactor systems. In addition, stabilization using several different binding agents has been demonstrated for reducing the leachability of metals in K061.

High temperature metals recovery is currently used to recover metals from hazardous waste for reuse; this technology also results in the formation of a treated residual (i.e., slag) with reduced concentrations of hazardous metals. The Agency collected treatment performance data for the five demonstrated high temperature metals recovery processes. The rotary kiln process, rotary hearth/electric furnace, plasma arc reactor, molten slag reactor, and flame reactor systems are based on similar principles; however, their design and operation are different. A more detailed discussion of the principles of high temperature metals recovery and descriptions of these systems is provided in Section 3.2.1. Performance data collected by EPA for high temperature metals recovery are also presented in Tables 3-1 to 3-17.

Stabilization is used to reduce the leachability of metals in K061 waste. It does not result in any recovery of metals or reduction in the

composition of the BDAT list metal constituents. The stabilization of K061 is a demonstrated technology for reducing the leachability of BDAT list metals from the residual to be land disposed, and therefore, also was selected by the Agency for testing. The Agency collected treatment performance data for several stabilization processes demonstrated on K061 waste. Performance data collected by EPA for stabilization are presented in Tables 3-18 to 3-27. A detailed description of stabilization processes is presented in Section 3.2.3.

3.2.1 High Temperature Metals Recovery

High temperature metals recovery provides for recovery of metals from wastes primarily by volatilization of the metals to be recovered, subsequent condensation from the gas phase, and product collection steps. The process yields metal products for reuse and substantially reduces the concentration of metals in the residual. This process also reduces the volume of treated waste that requires land disposal.

(1) Applicability and use of high temperature metals recovery. This process is applicable to the treatment of wastes containing BDAT list metals, low to moderate water content (or a water content that can either be blended to the required level or lowered by dewatering), and low concentration of organics. This technology is applicable to a wide variety of metals including cadmium, chromium, lead, mercury, nickel, and zinc. The five high temperature metals recovery processes that have been demonstrated for K061 are: the rotary kiln process, rotary hearth/electric furnace, the plasma arc reactor, the molten slag reactor,

and flame reactor systems. These technologies are designed to recover metals from K061 wastes through high temperature reduction, volatilization, and product collection steps. Also generated are treatment residuals that have reduced hazardous metals concentration and low leachability, however, in some cases, the treatment residual (sometimes referred to as slag) can be drastically reduced in volume or even eliminated. This can occur if the iron content is converted to the metallic form rather than the oxide form and can be recycled to steel production as feed material. High temperature metals recovery is particularly applicable because it is a reuse/waste minimization technology, which is consistent with EPA's desire to reduce the land disposal of hazardous waste.

(2) Underlying principles of operation. The theory of operation of high temperature metals recovery is that sufficient heat is transferred to the waste to separate metal constituents through volatilization in a reducing atmosphere. The volatile metals can then be recovered for reuse. An example of the chemical reduction reaction would be:

$$2ZnO + C \rightarrow 2Zn + CO_2$$

In some cases, multiple products may be collected from high temperature metals recovery if the waste contains not only BDAT list metal constituents that can be volatilized but also nonvolatile BDAT list metals as well.

In the first processing step, the metal oxides are reduced to their metallic form in the presence of carbon, which is provided in the form of

coal or coke. Heat transfer is externally supplied by burning fossil fuels (natural gas, coal, coke, etc.), electricity, or molten slag from other steel production operations. In some cases, the reaction can be exothermic and may only need enough energy to initiate the reaction. Once reduced to their metallic form, the volatile metals, primarily cadmium, zinc, and lead, escape from the other feed materials. The gaseous metals may be reoxidized and collected in a baghouse or wet scrubber, or they may be condensed and recovered in the metallic form. There is no difference between these two types of metal product recovery systems relative to the kinds of waste that can be treated; the difference is simply reflected in a facility's preference relative to product purity. In the former case, the direct condensation of metals, while more costly, allows for the separation and collection of metals in a relatively uncontaminated form; in the latter case the metals are collected as a combination of several metal oxides. If necessary, this combination of metal oxides could be further processed to produce individual metal products of increased purity.

The fraction of the waste that isn't originally volatilized has three possible dispositions: 1) the material is such that it can be used directly as a product (e.g., a waste residual containing mostly metallic iron can be reused directly in steelmaking), 2) the material can be reused after further processing (e.g., a waste residual containing oxides of iron, chromium, and nickel can be reduced to the metallic form and

then recovered for use in the manufacture of stainless steel), and 3) the material has no recoverable value and is land disposed as a slag.

(3) Description of high temperature metals recovery processes. These processes essentially consist of four operations: (1) a blending operation to control feed parameters, (2) high temperature processing, (3) volatile product collection systems, and (4) handling of the less volatile treated residual. As stated previously, the five high temperature metals recovery systems operate on similar principles. Many steps and operations are present in all of these systems and will be described generally. Areas that differ in their design, operation, or equipment used, will be discussed separately. A generic schematic diagram for high temperature metals recovery is shown in Figure 3-1.

K061 in the form of a baghouses dust or a sludge from a wet scrubber can be treated by high temperature metals recovery. In some cases, it may be necessary to reduce the water content of the waste prior to treatment. This can be accomplished mechanically or by blending wastes.

Variations in feeds can be minimized by blending various wastes from different sources or from different batches of steel production over time. Prior to feeding the kiln, fluxing agents and carbon are added to the waste as required. Carbon is supplied to reduce metal oxides to their metallic states as the reducing agent. The fluxes (limestone or sand) and other additives may be blended with the waste to improve the recovery of volatile metals. In some cases, these feeds are pelletized prior to processing, while in others they may be input directly to the

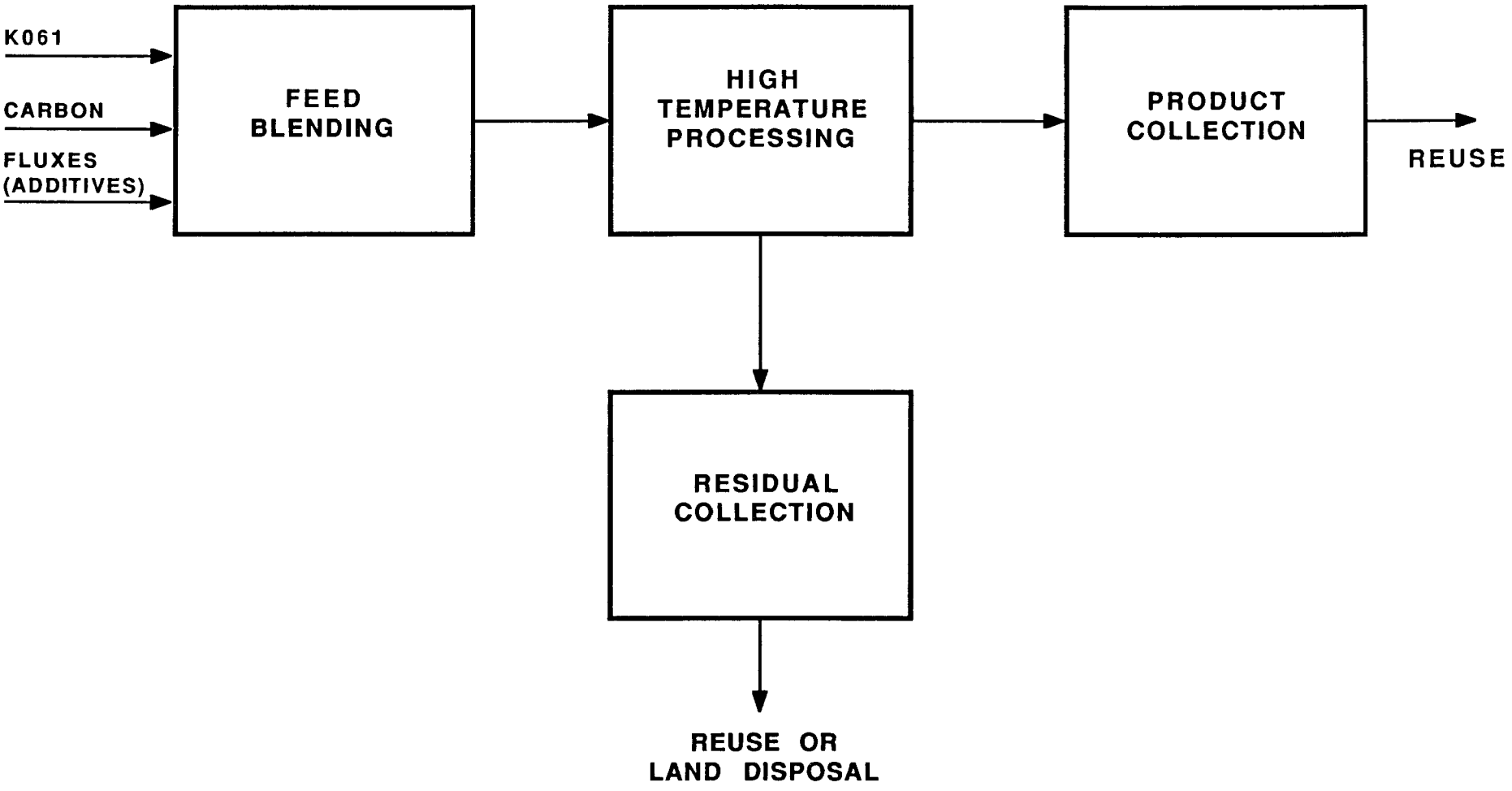

FIGURE 3-1 EXAMPLE HIGH TEMPERATURE METALS RECOVERY SYSTEM

process. Below are descriptions of the five demonstrated high temperature metals recovery process: (a) rotary kiln process, (b) plasma arc reactor, (c) rotary hearth/electric furnace, (d) molten slag reactor system, and (e) flame reactor.

(a) Rotary kiln process. The rotary kiln process was designed to treat zinc bearing ores and has been adapted to recover zinc from electric furnace dust (K061). The feed materials (K061, coal, fluxes) are blended and input to the kiln where they are heated and the reduction reactions begin. Volatile metals including zinc, cadmium, and lead are removed from the waste and concentrated in a zinc rich product. These volatile metals can be collected as oxidized particulates or can be condensed and collected in the metallic form. In some rotary kiln processes, an air stream is fed into the kiln countercurrent with the waste. The air stream flowing through the kiln provides the means to physically separate the product from the slag. As the volatile metals escape from the kiln, they are reoxidized and condensed in the air stream as particles. The enriched metal oxide particles are swept out of the kiln in the air stream and are collected in a baghouse, as a product. This material is sent for further refining to produce a final zinc product.

The residual slag exits the kiln, is quenched by water, and is collected. High evaporation rates of quench water result in a net loss of water and eliminate the need for wastewater discharge. The slag, now being reduced in both volume and concentration of metals is sometimes

land disposed, although it can be recycled back to steel production if the iron is sufficiently metallized. This can be beneficial when treating K061 from specialty steel production which may contain high concentrations of chromium and nickel, which are concentrated with the iron in the slag.

(b) Plasma arc reactor. The plasma arc process is designed to recover zinc, lead, cadmium, chromium, and iron from electric furnace dust. The system can be used to treat emission control dust from carbon steel production or specialty steel production. The feed (K061, coal, and fluxes) is fed into the lower section of a shaft furnace where the metals are reduced in the presence of coal. The high temperatures generated by the plasma arc vaporize the more volatile metals such as zinc, lead, and cadmium, which are condensed and collected as products. In addition, an iron product is generated by the process and is recycled to steel producers. The process also generates a slag and sludge.

(c) Rotary hearth/electric furnace process. The rotary hearth/electric furnace process is designed to recover a product containing iron, chromium, and nickel for reuse in specialty steel making, along with a zinc dust. This process is especially applicable for high chromium and nickel dusts from specialty steel production because the iron is metallized and also contains chromium and nickel for recycle to specialty steel making. The waste is pelletized along with coal or coke prior to treatment. The treatment process primarily consists of two treatment steps: (1) reducing metallic oxides and

volatilizing zinc and lead in a rotary hearth and (2) producing the final iron product in an electric furnace. The function of the rotary hearth is similar to that of the rotary kiln. Metallic oxides are reduced and a volatile product containing zinc and lead is recovered in a wet scrubber for reuse. The remaining metal is then resmelted in an electric furnace. During this second step, the metals volatilized from the waste are collected in a baghouse, and the zinc and lead are recovered for reuse. The iron product (containing chromium and nickel) is cast into ingots and recycled to specialty steel producers. A slag is generated from the process which requires land disposal.

(d) Molten slag reactor system. The molten slag reactor system is designed to recover zinc from electric furnace dust through high temperature reduction and volatilization. The K061 is pelletized with coal and injected into a molten slag, which supplies the heat for reduction and volatilization. The coal serves as the reducing agent and special additives are included to improve product recovery. Auxiliary heat can be supplied if necessary by an oil burner. A zinc oxide product is collected in a baghouse for reuse and the remaining slag is land disposed.

(e) Flame reactor. The flame reactor is carbon-fueled flash smelting process designed to recover zinc and lead from electric furnace dust/sludge. In the reactor, coke is mixed with oxygen at high temperatures. The K061 is directly injected into the reactor where the metals are reduced. The volatile metals (zinc, lead, cadmium) are

collected with a baghouse and a residual slag is also generated. Generally, this slag is land disposed.

(4) Waste characteristics affecting performance. Consistent with the theory of its design, the waste characteristics that affect high temperature metals recovery are those that inhibit volatilization of metals from the waste and the recovery of metallic products. In determining whether high temperature metals recovery technologies are likely to achieve the same level of performance on an untested waste as on a previously tested waste, EPA will examine the following three waste characteristics that have an impact on treatability: (a) type of metals in the waste, (b) relative volatility of the metals, and (c) heat transfer characteristics of the waste.

(a) Type of metals in the waste. Because this is a metals recovery process, the products must meet certain requirements for reuse. The purity of the product is a direct function of the constituents in the waste and their relative volatilities. If the waste contains other metals that are difficult to separate and whose presence may affect the ability to refine the products for reuse, high temperature metals recovery may provide less effective treatment. The metal constituents that compose K061 waste can be analyzed by EPA Method 6010 from SW-846.

(b) Volatility. The relative volatilities of the metals in the waste also affect the ability to separate various metals. Depending on the composition of the waste, the high temperature metals recovery system used, and the metal constituents being recovered, different metals will

be concentrated in the volatile products and the residual slag. As a result, undesirable metals may be present in products if their volatilities are similar. There is no conventional measurement technique for determining the relative volatility of metal constituents in a given waste. EPA believes that the best measure of volatility of a given constituent is the boiling point. EPA recognizes that boiling point has certain shortcomings, primarily the fact that boiling points are given for pure components, while clearly the other constituents in the waste will affect partial pressures and, thus, the boiling point of the mixture. EPA has not identified a parameter that can better assess relative volatility. Boiling points of metals can be found in a variety of scientific handbooks.

(c) Heat transfer characteristics. The ability to heat and volatilize constituents within a waste matrix is a function of the heat transfer characteristics of a heterogeneous waste material. The constituents being volatilized from the waste must be heated near or above their boiling points in order for them to be volatilized and recovered. Within a given treatment unit, whether sufficient heat will be transferred to the particular constituent to cause the metal to volatilize will depend on the heat transfer characteristics of the waste. There is no conventional direct measurement of the heat transfer characteristics of a waste. EPA believes that the best measure of heat transfer characteristics of the waste is thermal conductivity. The analytical method that EPA has identified for measurement of thermal

conductivity is named "Guarded, Comparative, Lungitudinal Heat Flow Technique," it is described in Appendix E.

(5) Design and Operating Parameters

Consistent with the theory of operation, these processes are designed so that sufficient heat is transferred to the waste in order to assure that the volatile metal constituents can be removed from the waste. The parameters that EPA will evaluate when determining whether a high temperature metals recovery system is well designed and well operated are (a) the furnace temperature, (b) the furnace residence time, (c) the amount and ratio of the feed blending materials, and (d) mixing. Below is an explanation of why EPA believes these parameters are important to an analysis of the design and operation of the system.

(a) Furnace Temperature. In order for volatilization to occur, sufficient heat must be transferred to the waste. The treatment system must be designed to provide high temperatures for reduction and volatilization. The higher the temperature, the more likely the constituents are to react with carbon to form free metals and volatilize. The volatility of the metals in the waste and the metals to be recovered thus determine the specific temperature for the system. Excessive temperatures may volatilize less volatile, undesirable metals into the product, inhibiting its potential for reuse. If the temperature is low, incomplete vaporization of volatile metals may occur, resulting in poor recoveries of metals from the waste. In assessing treatment performance, EPA would want continuous temperature data.

(b) Furnace Residence Time. The system must be designed to ensure that the waste has sufficient time to be heated to a temperature where the metals will be volatilized. The residence time necessary for complete volatilization of these constituents is dependent on the system temperature and the heat transfer characteristics of the waste. In practice, the residence time is a function of the physical dimensions of the system (length, diameter) and the feed rate. For the rotary kiln and rotary hearth/electric furnace systems, the rate of rotation also impacts residence time. The molten slag reactor system is a batch process and residence time is controlled by the system operator.

(c) Amount and Ratio of Feed Blending Materials. High temperature metals recovery systems must be designed with respect to the waste being treated so that metals recovery is successfully accomplished. Uniform feed conditions with regard to metals content, water content, carbon content, and calcium to silica ratio must be provided for most effective treatment. Then parameters affect the rate of reduction and volatilization of metals. The system can be designed for the treatment of a particular waste, or various wastes may be blended together to minimize variations in feed composition. Different wastes may be blended from several sources or over time from steel production at one facility. Additionally, coal, fluxes, and other additives must be blended with the waste to attain the proper feed conditions. EPA will examine blending ratios during treatment to ensure that they comply with the design values.

(d) Mixing. The system must mix the waste sufficiently enough so that the material is uniformly heated and is exposed to the surface so that the metal constituents can volatilize. Accordingly, EPA will examine the type and degree of mixing involved when assessing treatment design and performance. In the case of the rotary kiln process and the rotary kiln/electric furnace system, this turbulence is provided by the rotary motion and depends on the rate of rotation. Mixing in the plasma arc process is provided by the injection system, which delivers a fine, granular feed material into the furnace by pressurized air. Oxygen injected into the molten slag bath provides turbulence in the molten slag reactor.

3.2.2 Performance Data for High Temperature Metals Recovery

The Agency collected 15 data sets for treatment of K061 by high temperature metals recovery. A data set constitutes a paired set of untreated and treated total composition analyses and the associated design and operating values for the treatment process. For high temperature metals recovery, treatment performance is based on the reduction of metal constituents and the leachability of the metals in the residual. Tables 3-1 to 3-17 summarize the treatment performance data collected for high temperature metals recovery.

Specifically, Tables 3-1 to 3-9 present the treatment performance data for high temperature metals recovery by the rotary kiln process.

Table 3-1 summarizes the ranges of composition of BDAT list metals for three data sets collected by the Agency representing a well operated rotary kiln system (Sample Sets #3, #4, and #7). Additionally, the data show the reduction in concentration of the BDAT list metal constituents that are present in the untreated waste in the highest concentrations: zinc, lead, cadmium, and chromium. The table also presents the low leachability of the treated residual as determined by the TCLP. Tables 3-2 to 3-8 present the seven analytical data sets (untreated total composition, treated total composition, treated-TCLP) collected by EPA for this treatment system. The waste characteristics affecting performance and the design and operating data collected during sampling of this rotary kiln process are presented in Table 3-9.

The waste characteristics affecting performance for the rotary kiln system are those characteristics which impact the volatility of metals and the recovery of reusable products. Both the boiling point of the metals and their concentrations affect volatility. The purity of the volatilized product is impacted by the presence of other metals with similiar volatilities. For example, if mercury were present in very high concentrations in the waste, it would be concentrated in the product. The result may be the generation of a volatilized product with little or no potential for reuse.

Performance data for the plasma arc reactor system are presented in Tables 3-10 and 3-11. These data show the variability in performance and the composition of the various treatment residuals including slags, and sludges. Additionally, the ranges of untreated waste compositions vary

considerably. These variations may be attributed to different steel grades being produced and the source of scrap used. Table 3-10 represents treatment of K061 from stainless steel production while Table 3-11 presents data for K061 from carbon steel production.

Tables 3-12 to 3-14 present TCLP data for untreated and treated wastes from the rotary hearth/electric furnace system. These data show the reduction in leachability of chromium, lead, zinc, and cadmium in the treated waste following reduction and volatilization in the rotary hearth.

Tables 3-15 and 3-16 present the performance data for the molten slag reactor system. Table 3-15 shows the treatment provided based on total composition for cadmium, chromium, lead, and zinc, while Table 3-16 provides EP Toxicity procedure leachate data for cadmium, chromium, and lead. Table 3-17 presents one data set collected for the flame reactor system. These data display the treatment provided for cadmium, chromium, lead, and zinc based on total concentration.

For all of the data and information submitted by industry on high temperature metals recovery, see the Administrative Record for K061.

Table 3-1 Summary of Treatment Performance Data for High Temperature Metals Recovery (Rotary Kiln)*
EPA Collected Data

BDAT Constituent	Untreated Concentration Range (ppm)	Treated Concentration Range (ppm)	Treated TCLP Range (mg/l)
Antimony	73 - 80	155 - 405	0.344 - 0.853
Arsenic	56 - 127	75 - 113	<0.010 - 0.013
Barium	184 - 204	345 - 467	2 93 - 4.32
Beryllium	<0.5 - 1.5	1.7 - 4.0	<0 001 - 0.002
Cadmium	394 - 808	<15	<0.060
Chromium	903 - 1,190	476 - 978	<0.080
Copper	1,590 - 2,640	3,190 - 5,470	<0.080
Lead	15,500 - 20,800	365 - 2,370	<0.025
Mercury	1 0 - 1 6	<0 1	<0 0002 - 0.0027
Nickel	261 - 449	579 - 952	0.024 - 0.153
Selenium	5.2 - 20	4.2 - 8.8	<0.005
Silver	23 - 44	39 - 59	<0.080
Thallium	<1.0 - 1.5	<0 1	<0.010
Vanadium	25 - 37	31 - 44	<0.060
Zinc	135,000 - 155,000	4,550 - 11,200	0.080 - 0.241

*These data represent three test runs that represent treatment by a well operated rotary kiln system (Sample Set #3, #4, and #.').

Reference 20 - Onsite Engineering Report for Horsehead Resource Development Co.

Table 3-2 High Temperature Metals Recovery (Rotary Kiln)
EPA Collected Data

Sample Set #1

	BDAT Constituents Detected		
	Untreated Concentration (ppm)	Treated Concentration (ppm)	Treated TCLP (mg/l)
Antimony	89	196	<0.021
Arsenic	59	77	<0.010
Barium	169	348	1.42
Beryllium	0.55	1 9	0.001
Cadmium	737	<15	<0.060
Chromium	905	662	<0.080
Copper	2,080	3,180	<0.004
Lead	19,400	1,720	<0.025
Mercury	1.4	<0 1	<0.0002
Nickel	184	434	0.203
Selenium	13	2 5	<0.025
Silver	30	32	<0.004
Thallium	2.7	<1.0	<0 010
Vanadium	24	8.6	<0.060
Zinc	129,000	24,300	2.64

Reference 20 - Onsite Engineering Report for Horsehead Resource Development Co.

Table 3-3 High Temperature Metals Recovery (Rotary Kiln)
EPA Collected Data

Sample Set #2

	BDAT Constituents Detected		
	Untreated Concentration (ppm)	Treated Concentration (ppm)	Treated TCLP (mg/l)
Antimony	65	187	0.795
Arsenic	55	77	0.068
Barium	164	363	2.66
Beryllium	<0.5	1.9	0.017
Cadmium	345	<15	<0.060
Chromium	959	741	0.103
Copper	1,620	3,370	0.100
Lead	14,900	2,080	<0.025
Mercury	1.4	<0 1	<0.0002
Nickel	285	422	1.40
Selenium	18	5.7	<0.025
Silver	23	35	0.099
Thallium	1 5	<1 0	<0.010
Vanadium	26	20	<0.060
Zinc	145,000	23,600	65.7

Reference 20 - Onsite Engineering Report for Horsehead Resource Development Co.

Table 3-4 High Temperature Metals Recovery (Rotary Kiln)
EPA Collected Data

Sample Set #3

	BDAT Constituents Detected		
	Untreated Concentration (ppm)	Treated Concentration (ppm)	Treated TCLP (mg/l)
Antimony	73	162	0.769
Arsenic	56	75	0.013
Barium	184	346	4.32
Beryllium	0 81	1.9	<0.001
Cadmium	394	<15	<0.060
Chromium	1,190	748	<0.080
Copper	1,980	3,290	<0.080
Lead	15,500	1,940	<0.025
Mercury	1 0	<0 1	<0.0002
Nickel	449	579	0.097
Selenium	5.2	4.2	<0.005
Silver	23	42	<0.080
Thallium	1.5	<1.0	<0.010
Vanadium	37	32	<0.060
Zinc	145,000	11,200	0.241

Reference 20 - Onsite Engineering Report for Horsehead Resource Development Co.

Table 3-5 High Temperature Metals Recovery (Rotary Kiln)
EPA Collected Data

Sample Set #4

	BDAT Constituents Detected		
	Untreated Concentration (ppm)	Treated Concentration (ppm)	Treated TCLP (mg/l)
Antimony	80	405	0.853
Arsenic	65	113	<0.010
Barium	190	467	2.93
Beryllium	1 5	4.0	0.002
Cadmium	808	<15	<0.060
Chromium	903	978	<0.080
Copper	2,640	5,470	<0.004
Lead	20,800	365	<0 025
Mercury	1.6	<0.1	0.0027
Nickel	261	952	0.153
Selenium	8.2	5.2	<0.005
Silver	29	39	<0.004
Thallium	1.3	<0.5	<0.010
Vanadium	25	44	<0.060
Zinc	135,000	4,680	0.128

Reference 20 - Onsite Engineering Report for Horsehead Resource Development Co.

Table 3-6 High Temperature Metals Recovery (Rotary Kiln)
EPA Collected Data

Sample Set #5

	BDAT Constituents Detected		
	Untreated Concentration (ppm)	Treated Concentration (ppm)	Treated TCLP (mg/l)
Antimony	52	146	0.700
Arsenic	56	105	<0.010
Barium	168	383	2.64
Beryllium	0 83	3.3	0.022
Cadmium	857	<15	<0.060
Chromium	803	205	<0.080
Copper	2,610	4,560	<0.080
Lead	21,900	738	<0.025
Mercury	2 0	<0.1	<0.0002
Nickel	202	588	0.445
Selenium	4.2	3 6	<0.025
Silver	25	33	<0.080
Thallium	0.75	<1.0	<0.010
Vanadium	27	<1.5	<0.060
Zinc	145,000	6,710	26.7

Reference 20 - Onsite Engineering Report for Horsehead Resource Development Co.

Table 3-7 High Temperature Metals Recovery (Rotary Kiln)
EPA Collected Data

Sample Set #6

	BDAT Constituents Detected		
	Untreated Concentration (ppm)	Treated Concentration (ppm)	Treated TCLP (mg/l)
Antimony	58	111	0.532
Arsenic	42	76	<0.010
Barium	193	331	2.35
Beryllium	<0.5	2.6	<0.001
Cadmium	298	<15	<0.060
Chromium	909	477	<0.080
Copper	1,460	3,610	<0.080
Lead	15,400	4,270	0.046
Mercury	1.1	<0.1	<0.0002
Nickel	234	460	0.579
Selenium	8.0	4.4	<0.025
Silver	37	32	<0.080
Thallium	<1.0	<1.0	<0.010
Vanadium	34	16	<0.060
Zinc	148,000	27,400	61.1

Reference 20 - Onsite Engineering Report for Horsehead Resource Development Co.

Table 3-8 High Temperature Metals Recovery (Rotary Kiln)
EPA Collected Data

Sample Set #7

	BDAT Constituents Detected		
	Untreated Concentration (ppm)	Treated Concentration (ppm)	Treated TCLP (mg/l)
Antimony	78	155	0.344
Arsenic	127	79	<0.010
Barium	204	381	3.690
Beryllium	<0.5	1.7	<0.001
Cadmium	290	<15	<0.060
Chromium	1,080	476	<0.080
Copper	1,590	3,190	<0.040
Lead	16,400	2,370	<0.025
Mercury	1 1	<0 1	<0.0002
Nickel	295	683	0.024
Selenium	20	8.8	<0.005
Silver	44	59	<0.040
Thallium	<1.0	<1 0	<0.010
Vanadium	33	31	<0.030
Zinc	155,000	4,550	0.080

Reference 20 - Onsite Engineering Report for Horsehead Resource Development Co.

Table 3-9 High Temperature Metals Recovery (Rotary Kiln)
Design and Operating Data and Waste Characteristics Affecting Performance
EPA Collected Data

Waste Characteristics Affecting Performance*

Boiling Point (in increasing order)

Mercury	356°C
Cadmium	765°C
Zinc	907°C
Lead	1760°C
Chromium	2672°C

Type of metal - No low boiling point metals are present in concentrations that could impact product purity and use.

Thermal Conductivity** - The thermal conductivity of K061 has been estimated to be approximately 28 Btu/hr-ft°F.

* The waste charaterictics affecting performance for high temperature metals recovery are volatility and heat transfer characteristics of the waste. EPA is using, as the best approximate measure of the parameters, boiling point and thermal conductivity.

** Calculated based on major constituents present in waste and their respective thermal conductivities This calculation can be found in the Administrative Record for K061

DESIGN AND OPERATING DATA

Parameter	Design Value	Operating Value						
		SS #1	SS #2	SS #3	SS #4	SS #5	SS #6	SS #7
Kiln Temperature (°C)								
Feed Rate (tons/hr)								
Rate of Rotation (min/rev)								
Zinc Content (%)		The information in this table has been claimed confidential business information (CBI) by the company providing it.						
Moisture Content (%)								
Carbon Content (%)								
Calcium/Silica Ratio								

Reference 20 - Onsite Engineering Report for Horsehead Resource Development Co.

Table 3-10 High Temperature Metals Recovery (Plasma Arc Reactor)
Sample Set #1
(Stainless Steel)

	BDAT Constituents Detected		
	Untreated Waste (ppm)	Treated Waste slag (ppm)	Treated Water (mg/l)
Antimony	-	20	0.100
Arsenic	-	2.1	<0.04
Barium	-	<200	<0.250
Beryllium	-	-	0.0014
Cadmium	100-600	<2	<0.002-0.004
Chromium	60,000-100,000	40,000-170,000	0.05-0 10
Copper	600-3,000	10	0.10-0.14
Lead	6,000-14,000	<5	<0.01
Mercury	0 7-16	<1	0.0001-0 0011
Nickel	15,000-22,000	300-2,200	<0.01-0 02
Selenium	-	-	0.450
Silver	-	-	-
Thallium	-	-	-
Vanadium	-	-	-
Zinc	22,000-53,000	50-98	0.05-0.10

- = No data

Reference 32 - SKF Plasmadust Data

Table 3-11 High Temperature Metals Recovery (Plasma Arc Reactor)
Sample Set #2
(Carbon Steel)

	BDAT Constituents Detected				
	Untreated Waste (ppm)	Treated Waste (slag) (ppm)	Treated Waste (slag) TCLP (ppm)	Treated Sludge (ppm)	Treated Water (mg/l)
Antimony	50-150	<20	-	<20	0.020-0.100
Arsenic	<100-400	<4-13	<0.005	1.6	<0.040
Barium	-	<3,000	2.5	<200	0.02-0.140
Beryllium	-	-	-	-	0.00016-0.00021
Cadmium	200-900	<10-500	<0.005	550	0.005-0 018
Chromium	400-5,000	2,000-12,000	0.013	23	0.03-0.08
Copper	1,500-2,800	10-1,500	-	-	0.05-0.30
Lead	24,000-50,000	50-1,500	<0 05	900	<0.01-0 01
Mercury	7-41	<5	<0 0002	0.59	0.0013-0.006
Nickel	1,000-3,000	200-1,000	0.22	-	<0.01-0.03
Selenium	-	-	<0 05	-	<0.040
Silver	-	-	0.014	-	-
Thallium	-	-	-	-	-
Vanadium	-	-	<0.02	<1,000	-
Zinc	150,000-320,000	50-2,000	-	3,500	0.05-0 08

- = No data

Reference 32 - SKF Plasmadust Data

Table 3-12 High Temperature Metals Recovery
(Rotary Hearth/Electric Furnace)

Sample Set #1

Constituent	Untreated Waste TCLP (ppm)	Treated Waste TCLP (ppm)
Chromium(+6)	213	0.62
Chromium	256	0 65

Reference 23 - INMETCO Data for Rotary Hearth/Electric Furnace

Table 3-13 High Temperature Metals Recovery
(Rotary Hearth/Electric Furnace)

Sample Set #2

Constituent	Untreated Waste TCLP (ppm)	Treated Waste TCLP (ppm)
Lead	0.39	0.35
Chromium	6.8	0.40
Chromium(+6)	5.4	0.28

Reference 23 - INMETCO Data for Rotary Hearth/Electric Furnace

Table 3-14 High Temperature Metals Recovery
(Rotary Hearth/Electric Furnace)

Sample Set #3

Constituent	Untreated Waste TCLP (ppm)	Treated Waste TCLP (ppm)
Lead	365	0 38
Zinc	4973	0.94
Cadmium	56	0.05
Chromium	<0.1	<0.10

Reference 23 - INMETCO Data for Rotary Hearth/Electric Furnace

Table 3-15 High Temperature Metals Recovery
(Molten Slag System)

Sample Set 1

	BDAT Constituents Detected	
	Untreated Waste (ppm)	Treated Slag (ppm)
Antimony	-	-
Arsenic	trace	trace
Barium	-	-
Beryllium	-	-
Cadmium	600	trace
Chromium	3,900	6,500
Copper	-	-
Lead	4,500	200
Mercury	-	-
Nickel	-	-
Selenium	-	-
Silver	-	-
Thallium	-	-
Vanadium	-	-
Zinc	188,200	12,200

- = No data.

Reference 33 - Sumitomo Molten Slag Data

Table 3-16 High Temperature Metals Recovery
(Molten Slag System)

Sample Set #2

	BDAT Constituents Detected	
	Untreated Waste EP Tox (ppm)	Treated Slag EP Tox (ppm)
Antimony	-	-
Arsenic	-	-
Barium	-	-
Beryllium	-	-
Cadmium	20.2-30 0	0.01-0.07
Chromium	0 7-1.4	0.04-0.3
Copper	-	-
Lead	348-556	0.05-0.80
Mercury	-	-
Nickel	-	-
Selenium	-	-
Silver	-	-
Thallium	-	-
Vanadium	-	-
Zinc	-	-

- = No data.

Reference 33 - Sumitomo Molten Slag Data

Table 3-17 High Temperature Metals Recovery (Flame Reactor)

	BDAT Constituents Detected	
	Untreated Waste (ppm)	Treated Waste (ppm)
Antimony	-	-
Arsenic	-	-
Barium	-	-
Beryllium	-	-
Cadmium	1,000	50
Chromium	8,000	13,000
Copper	-	-
Lead	30,000	2,000
Mercury	-	-
Nickel	-	-
Selenium	-	-
Silver	-	-
Thallium	-	-
Vanadium	-	-
Zinc	220,000	40,000

- = No Data

Reference 32 - St Joe Flame Reactor Data

3.2.3 Stabilization of Metals

Stabilization refers to a broad class of treatment processes that chemically reduce the mobility of hazardous metal constituents in a waste. Solidification and fixation are other terms that are sometimes used synonymously for stabilization or to describe specific variations within the broader class of stabilization. Related technologies are encapsulation and thermoplastic binding; however, EPA considers the technologies to be distinct from stabilization in that the operational principles are significantly different.

(1) Applicability and use of stabilization. Stabilization is used when a waste contains metals that will leach from the waste when it is contacted by water. In general, this technology is applicable to wastes containing BDAT list metals having a high filterable solids content, low TOC content, and low oil and grease content. Stabilization has been applied to electric furnace dust (K061) to reduce the leachability of hazardous metal constituents. This technology does not destroy, recover, or otherwise change the waste constituents, but is used to prevent metals from leaching.

(2) Underlying principles of operation. The basic principle underlying this technology is that stabilizing agents and other chemicals are added to a waste in order to minimize the amount of metal that leaches. The reduced leachability is accomplished by the formation of a lattice structure and/or chemical bonds that bind the metals to a solid

matrix and, thereby, limit the amount of constituents which can be leached when water or a mild acid solution comes into contact with the material.

The two principal stabilization processes used are the cement based process and the lime/pozzolan-based process. A brief discussion of each is provided below. In both cement-based and lime/pozzolan-based techniques, the stabilizing process can be modified through the use of additives, such as silicates, that control curing rates or enhance the properties of the solid material.

(a) Portland cement-based process. Portland cement is a mixture of powdered oxides of calcium, silica, aluminum, and iron, produced by kiln burning of materials rich in calcium and silica at high temperatures (i.e., 1400 to 1500°C). When the anhydrous cement powder is mixed with water, hydration occurs and the cement begins to set. The chemistry involved is complex because many different reactions occur, depending on the composition of the cement mixture.

As the cement begins to set, a colloidal gel of indefinite composition and structure is formed. Over a period of time, the gel swells and forms a matrix composed of interlacing, thin, densely-packed silicate fibrils. Constituents present in the waste slurry, e.g., hydroxides and carbonates of various heavy metals, are incorporated into the interstices of the cement matrix. The high pH of the cement mixture tends to keep metals in the form of insoluble hydroxide and carbonate salts. It has been hypothesized that metal ions also may be incorporated

into the crystal structure of the cement matrix, but this hypothesis has not been verified.

(b) Lime/pozzolan-based process

Pozzolan, which contains finely divided, noncrystalline silica (e.g., fly ash or components of cement kiln dust), is a material that is not cementitious in itself, but becomes so upon the addition of lime. Metals in the waste are converted to silicates or hydroxides which inhibit leaching. Additives, again, can be used to reduce permeability and thereby further decrease leaching potential.

(3) Description of stabilization processes. In most stabilization processes, the waste, stabilizing agent, and other additives, if used, are mixed and then pumped to a curing vessel or area and allowed to cure. The actual operation (equipment requirements and process sequencing) will depend on several factors such as the nature of the waste, the quantity of the waste, the locations of the waste, the curing rate, the disposal site location, the physical characteristics of the site, the particular stabilization formulation to be used, and the curing rate. After curing, the solid formed is recovered from the processing equipment and stripped for final disposal.

In instances where waste contained in a lagoon is to be treated, the material should be first transferred to mixing vessels where stabilizing agents are added. The mixed material is then fed to a curing pad or vessel. After curing, the solid formed is removed for disposal. Equipment commonly used also includes facilities to store waste and chemical additives. Pumps can be used to transfer liquid or light sludge

wastes to the mixing pits and pumpable uncured wastes to the curing site. Stabilized wastes are then removed to a final disposal site.

Commercial concrete mixing and handling equipment can generally be used with wastes. Weighing conveyors, metering cement hoppers, and mixers similar to concrete batching plants have been adapted in some operations. Unless severe corrosion occurs, no adaptation of equipment is required. Where extremely dangerous materials are being treated, remote control and in-drum mixing equipment, such as that used with nuclear waste, can be employed.

(4) Waste characteristics affecting performance. In determining whether stabilization is likely to achieve the same level of performance on an untested waste as on a waste previously tested, the Agency will focus on the characteristics that inhibit the formation of either the chemical bonds or the lattice structure. The four characteristics EPA has identified as affecting treatment performance are the presence of: (a) fine particulates, (b) oil and grease, (c) organic compounds, and (d) inorganic compounds (including sulfates and chlorides).

(a) Fine particulates. For both cement-based and lime/pozzolan-based processes, the literature states that very fine, insoluble materials (i.e., those that pass through a No. 200 mesh sieve, 74 um particle size) can weaken the bonding between waste particles and cement by coating the particles. This coating can inhibit chemical bond formation and thereby decrease the resistance of the material to leaching. Particle size can be measured by ASTM Method D422.

(b) Oil and grease. The presence of oil and grease in both cement-based and lime/pozzolan-based systems results in the coating of waste particles and the weakening of the bonding between the particle and the stabilizing agent. This coating can inhibit bond formation, thereby decreasing the resistance of the material to leaching. Oil and grease content can be measured by EPA Method 9070.

(c) Organic compounds. The presence of organic compounds in the waste interferes with the chemical reactions. This interference inhibits setting and decreases the resistance of the material to leaching. Total organic carbon can be measured by EPA Method 9060.

(d) Sulfates and chlorides. The presence of certain inorganic compounds will interfere with the chemical reactions, weakening bond strength, and prolonging setting and curing time. Sulfate and chloride compounds may reduce the diversional stability of the cured matrix, thereby increasing leaching potential. Chlorides can be measured by EPA Method 9252, and sulfates can be measured by EPA Method 9038. Accordingly, EPA will examine these constituents when making decisions regarding transfer of treatment standards based on stabilization.

(5) Design and operating parameters

In designing a stabilization system, the principal parameters that are important to optimize so that the amount of leachable metal constituents is minimized are: (a) the selection of stabilizing agents and other additives, (b) the ratio of waste to stabilizing agents and other additives, (c) the degree of mixing, and (d) curing conditions.

(a) Selection of stabilizing agents and other additives. The stabilizing agent and additives used will determine the chemistry and structure of the stabilized material and thus will affect the leachability of the solid material. Stabilizing agents and additives must be carefully selected based on the chemical and physical characteristics of the waste to be stabilized. For example, the amount of sulfates in a waste should be considered when a choice is being made between a lime/pozzolan-based system and a Portland cement-based system. In order to select the stabilizing agents and additives, the waste should be tested in the laboratory with a variety of materials to determine the best combination.

(b) Amount of stabilizing agents and additives. The amount of stabilizing agents and additives is a critical parameter in that sufficient stabilizing materials are necessary in the mixture to bind the waste constituents of concern properly, thereby making them less susceptible to leaching. The appropriate weight ratios of amounts of waste to stabilizing agent and other additives are established empirically by setting up a series of laboratory tests that allow separate leachate testing of different mix ratios. The ratio of water to stabilizing agent (including water in waste) will also impact the strength and leaching characteristics of the stabilized material. Too much water will cause low strength; too little will make mixing difficult and, more importantly, may not allow the chemical reactions that bind the hazardous constituents to be fully completed.

(c) Mixing. The conditions of mixing include the type and duration of mixing. Mixing is necessary to ensure homogeneous distribution of the waste and the stabilizing agents. Both undermixing and overmixing are undesirable. The first condition results in a nonhomogeneous mixture; therefore, areas can exist within the waste where waste particles are neither chemically bonded to the stabilizing agent nor physically held within the lattice structure. Overmixing, on the other hand, may inhibit gel formation and ion adsorption in some stabilization systems. As with the relative amounts of waste, stabilizing agent, and additives within the system, optimal mixing conditions can be determined through laboratory experiments. During treatment it is important to monitor the degree (i.e., type and duration) of mixing to ensure that it reflects design conditions.

(d) Curing conditions. Curing conditions include the duration of curing and the ambient curing conditions (temperature and humidity). The duration of curing is a critical parameter to ensure that the waste particles have had sufficient time in which to form stable chemical bonds and/or lattice structures. The time necessary for complete stabilization depends upon the waste type and the stabilization used. The performance of the stabilized waste (i.e., the levels of constituents in the leachate) will be highly dependent upon whether complete stabilization has occurred. Higher temperatures and lower humidity increase the rate of curing by increasing the rate of evaporation of water from the solidification mixtures. However, if temperatures are too high, the evaporation rate can be excessive and result in too little water being

available for completion of the stabilization reaction. The duration of the curing process should also be determined during the design stage and typically will be between 7 and 28 days.

3.2.4 Performance Data for Stabilization

The Agency collected 40 data sets for treatment of K061 by stabilization. Because stabilization is not used to reduce the concentration of metals in the waste but only to reduce the ability of metals to leach, treatment performance is measured by analysis of the leachate from the TCLP. A data set for stabilization consists of a paired set of untreated TCLP and treated TCLP values and the associated design and operating parameters. Tables 3-18 to 3-27 summarize the data collected for stabilization of K061.

Specifically, Table 3-18 summarizes the performance of stabilization of K061 as tested by the Agency. The data presented include the untreated waste composition and TCLP values and the TCLP extract of the treated waste. These data are the results of 9 test runs performed using three different binding agents: cement, kiln dust, and lime/fly ash. These data display a tremendous variability in the treatment provided for the BDAT metals using the different stabilizing agents. Generally, lead, and zinc achieve the greatest reduction in leachability. In several cases, however, the performance of stabilization for certain constituents (e.g., cadmium, zinc) varies by greater than one order of magnitude. In some instances, the leachability is increased by stabilization as is displayed for vanadium and chromium. Tables 3-19 to 3-21 display the particular performance results for the Agency's testing of the three

binding agents: cement, kiln dust, and lime/fly ash. It can be noted that there is not one binding agent that is most effective for all of the BDAT metals, because treatment performance varies for each metal with each binding agent. Table 3-22 presents the design and operating data including binder to waste ratios and water to waste ratios collected during the stabilization tests. Also presented are the waste characteristics that impact performance of stabilization and the values measured for the K061 waste tested by the Agency. Table 3-22 shows that the waste characteristics affecting performance for K061 are not favorable for stabilization (i.e., fine particles, sulfates, chlorides, and oil and grease).

Tables 3-23 through 3-27 are stabilization data for K061 submitted by industry. Table 3-23 represents 21 data points for the EP Toxicity extraction procedure from stabilized K061. The data include untreated waste concentration, untreated EP Toxicity extraction results and treated waste EP Toxicity extraction results for a few of the BDAT metals. Table 3-24 through 3-27 represent 10 data sets for stabilization of K061 submitted by industry. These data include EP Toxicity extraction results for both the untreated and treated waste for several BDAT metals. The treatment performance provided by these stabilization processes varies considerably for the metals analyzed. In some cases, the leachability of certain metals in the stabilized wastes increases based on the EP Toxicity extraction procedure. In other cases, little or no treatment is provided by stabilization.

For all of the data submitted by industry for stabilization, see the Administrative Record for K061.

Table 3-18 Summary of Treatment Performance Data for Stabilization* - EPA Collected Data

BDAT Constituents	Untreated Waste		Treated Waste
	Total (ppm)	TCLP (mg/l)	TCLP (mg/l)
Antimony	294	0.040	<0.050
Arsenic	36	<0 010	<0 010
Barium	238	0 733	0.431 - 0.670
Beryllium	0.15	<0.001	<0.001
Cadmium	481	12.8	0.033 - 3.64
Chromium	1,370	<0 007	0.027 - 0.093
Copper	2,240	0 066	<0.004 - 0.058
Lead	20,300	45.1	0.350 - 1.30
Mercury	3.8	0.0026	0.0005 - 0.0018
Nickel	243	0.027	<0.012 - 0.024
Selenium	<5 0	<0 050	<0.025
Silver	59	0.021	<0.003
Thallium	<1.0	0.038	<0.007 - 0.015
Vandium	25	<0.006	0.080 - 0.290
Zinc	244,000	445	0.179 - 23.5

*These data summarizes 9 data sets for stabilization of K061 using three binding agents: cement, kiln dust, and lime/fly ash.

Reference 21 - Onsite Engineering Report for Waterways Experiment Station for K061

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Table 3-19 Stabilization Testing* - EPA Collected Data

Test #1 - Binder Cement

BDAT Constituents	Untreated Waste Total (ppm)	Untreated Waste TCLP (mg/l)	Treated Waste - TCLP (mg/l) Run #1	Run #2	Run #3
Antimony	294	0.040	<0.050	<0.050	<0 050
Arsenic	36	<0.010	<0 010	<0.010	<0.010
Barium	238	0.733	0 670	0.550	0 516
Beryllium	0.15	<0.001	<0.001	<0.001	<0.001
Cadmium	481	12 8	2 86	3.64	3.38
Chromium	1,370	<0 007	0 049	0 039	0 040
Copper	2,240	0 066	0.058	0.009	0.005
Lead	20,300	45.1	1.03	1.20	1.24
Mercury	3.8	0.0026	0.0013	0.0014	0.0012
Nickel	243	0.027	0 024	0.014	0.018
Selenium	<5.0	<0.050	<0.010	<0.010	<0.010
Silver	59	0.021	<0.003	<0.003	<0.003
Thallium	<1 0	0.038	<0.007	0.013	0.015
Vanadium	25	<0.006	0.084	0.091	0.290
Zinc	244,000	445	21.0	23.5	23.4

*See Table 3-22 for the design and operating data collected for these stabilization tests.

Reference 21 - Onsite Engineering Report for Waterways Experiment Station for K061

Table 3-20 Stabilization Testing - EPA Collected Data

Test #2 - Binder Kiln Dust

BDAT Constituents	Untreated Waste Total (ppm)	Untreated Waste TCLP (mg/l)	Treated Waste - TCLP (mg/l) Run #4	Run #5	Run #6
Antimony	294	0.040	<0.050	<0 050	<0 050
Arsenic	36	<0.010	<0.010	<0.010	<0.010
Barium	238	0.733	0 516	0.454	0.552
Beryllium	0.15	<0 001	<0.001	<0.001	<0.001
Cadmium	481	12 8	2.92	1.80	0.508
Chromium	1,370	<0.007	0 027	0.035	0.034
Copper	2,240	0 066	0.019	<0.004	0.016
Lead	20,300	45.1	1.30	0.711	0.350
Mercury	3 8	0.0026	0.0005	0.0008	0.0009
Nickel	243	0.027	<0 012	<0 012	<0 012
Selenium	<5 0	<0.05	<0.010	<0.010	<0.010
Silver	59	0.021	<0.003	<0.003	<0.003
Thallium	<1 0	0 038	0 012	0.011	0.010
Vanadium	25	<0.006	0 083	0.088	0.091
Zinc	244,000	445	14 2	6.12	2.00

*See Table 3-22 for the design and operating data collected for these stabilization tests.

Reference 21 - Onsite Engineering Report for Waterways Experiment Station for K061

Table 3-21 Stabilization Testing - EPA Collected Data

Test #3 - Binder Lime/Fly Ash

BDAT Constituents	Untreated Waste Total (ppm)	Untreated Waste TCLP (mg/l)	Treated Waste - TCLP (mg/l) Run #7	Run #8	Run #9
Antimony	294	0.040	<0.050	<0.050	<0.050
Arsenic	36	<0.010	<0.010	<0.010	<0.010
Barium	238	0.733	0.462	0.431	0.500
Beryllium	0.15	<0.001	<0.001	<0.001	<0.001
Cadmium	481	12.8	0.033	0.049	0.073
Chromium	1,370	<0.007	0.093	0.072	0.053
Copper	2,240	0.066	0.015	<0.004	0.008
Lead	20,300	45.1	0.150	0.069	0.066
Mercury	3.8	0.0026	0.0016	0.0017	0.0018
Nickel	243	0.027	<0.012	<0.012	<0.012
Selenium	<5.0	<0.05	<0.025	<0.025	<0.010
Silver	59	0.021	<0.003	<0.003	<0.003
Thallium	<1.0	0.038	0.012	0.014	0.011
Vanadium	25	<0.006	0.080	0.089	0.085
Zinc	244,000	445	0.592	0.179	0.398

*See Table 3-22 for the design and operating data collected for these stabilization tests.

Reference 21 - Onsite Engineering Report for Waterways Experiment Station for K061

Table 3-22 Stabilization Testing - EPA Collected Data

Parameter	Design and Operating Data								
	Stabilization Process/Binder								
	Cement			Kiln Dust			Lime and Fly Ash		
	Run #1	Run #2	Run #3	Run #4	Run #5	Run #6	Run #7	Run #8	Run #9
Binder to Waste Ratio	0 05	0.05	0.05	0.05	0 05	0.05	-	-	-
Lime to Waste Ratio							0.05	0.05	0.05
Fly Ash to Waste Ratio							0.05	0.05	0.05
Water to Waste Ratio	0 5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Mixture pH	10 9	11.5	10.5	11.5	11.6	11.1	12.1	12.0	12.0
Cure Time (Days)	28	28	28	28	28	28	28	28	28
Unconfined Compressive Strength (lb/in^2)	59.7	88.8	95.7	133.0	167.2	141.2	54.6	58.0	50.7

Waste Characteristics Affecting Performance

Fine Particulates - 90% of the waste composed of particles <63 um or less than 230 mesh sieve size

Oil and Grease - 282 ppm

Sulfates - 8,440 ppm

Chlorides - 19,300 ppm

Total Organic Carbon - 4,430 ppm

Reference 21 - Onsite Engineering Report for Waterways Experiment Station for K061

Table 3-23 Stabilization Testing - Chemically Stabilized Electric Arc Furnace Dust (CSEAFD)

	BDAT Constituents Detected		
	Untreated[1] Waste (ppm)	Untreated[2] Waste EP Tox (ppm)	Treated[3] Waste EP Tox (ppm)
Antimony	-	-	-
Arsenic	40	-	-
Barium	400	-	-
Beryllium	-	-	-
Cadmium	600	1.7	0.02
Chromium	1,100	0.9	0.07
Copper	-	-	-
Lead	38,000	139	0.02
Mercury	2	-	-
Nickel	200	-	-
Selenium	<10	-	-
Silver	<50	-	-
Thallium	-	-	-
Vanadium	-	-	-
Zinc	167,000	-	-

[1] - Based on average of six samples

[2] - Mean of 12 values.

[3] - Mean value of 21 data points for EP Tox extract analyses.

- = No data.

Reference 15 - Bethlehem Steel (CSEAFD) Stabilization Data

Table 3-24 Stabilization Testing

Sample Set #1

BDAT Constituents Detected

	Untreated Waste EP TOX (ppm)	Treated Waste EP TOX (ppm)	
		Run #1	Run #2
Antimony	-	-	-
Arsenic	<0.01	0.07	0.05
Barium	<1	<1	<1
Beryllium	-	-	-
Cadmium	<0.01	0.27	<0.01
Chromium	1.38	0.06	0.05
Copper	-	-	-
Lead	<0 2	0.049	0.011
Mercury	<0.01	<0.01	<0.01
Nickel	<0 04	<0.1	<0.1
Selenium	0.021	0.051	0.045
Silver	<0.005	<0.05	<0.05
Thallium	-	-	-
Vanadium	-	-	-
Zinc	-	-	-

- = No Data.

Reference 26 - Lopat Enterprises Stabilization Data

Table 3-25 Stabilization Testing

Sample Set #2

BDAT Constituents Detected

	Untreated Waste EP TOX (ppm)	Treated Waste EP TOX (ppm)		
		Run #1	Run #2	Run #3
Antimony	-	-	-	-
Arsenic	3.0	0.01	0.01	<0.01
Barium	110	<1	<1	<1
Beryllium	-	-	-	-
Cadmium	4.44	<0.01	<0.01	<0.01
Chromium	0.08	0.23	0.10	0.84
Copper	-	-	-	-
Lead	40.0	0.006	0.027	0.18
Mercury	<0.01	<0.01	<0.01	<0.01
Nickel	NA	<0.1	<0.1	<0.1
Selenium	1.81	0.033	0 010	0.061
Silver	0.06	<0 05	<0.05	<0.05
Thallium	-	-	-	-
Vanadium	-	-	-	-
Zinc	-	-	-	-

- = No Data.

Reference 26 - Lopat Enterprises Stabilization Data

Table 3-26 Stabilization Testing

Sample Set #3

BDAT Constituents Detected

	Untreated Waste EP TOX (ppm)	Treated Waste EP TOX (ppm) Run #1	Run #2	Run #3
Antimony	-	-	-	-
Arsenic	0.02	0 02	0.14	0.11
Barium	3.0	<1.0	3	<1
Beryllium	-	-	-	-
Cadmium	<0.01	<0.01	<0.0	<0.01
Chromium	0.07	0.56	0.16	0.39
Copper	-	-	-	-
Lead	100	0 078	0 39	0.054
Mercury	<0.01	<0.01	<0.01	<0.01
Nickel	<0.1	<0.1	<0.1	<0.1
Selenium	0.009	0.024	0.034	0.063
Silver	<0.05	<0 05	<0.05	<0.05
Thallium	-	-	-	-
Vanadium	-	-	-	-
Zinc	-	-	-	-

- = No Data

Reference 26 - Lopat Enterprises Stabilization Data

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Table 3-27 Stabilization Testing

Sample Set #4

BDAT Constituents Detected

	Untreated Waste EP TOX (ppm)	Treated Waste EP TOX (ppm) Run #1	Run #2
Antimony	-	-	-
Arsenic	<0.1	<0 01	<0.01
Barium	2.2	<1	<1
Beryllium	-	-	-
Cadmium	0.023	0.03	0.02
Chromium	<0.03	0.21	<0.05
Copper	-	-	-
Lead	500	0.17	0.36
Mercury	0.0064	<0.01	<0.01
Nickel	NA	<0.1	<0.1
Selenium	<0.1	0.065	0.038
Silver	<0.02	<0.05	<0.05
Thallium	-	-	-
Vanadium	-	-	-
Zinc	-	-	-

- = No Data.

Reference 26 - Lopat Enterprises Stabilization Data

3.3 Other Applicable Treatment Technologies

The Agency is aware that other existing treatment technologies may be applicable to K061. Generally, these technologies have not been demonstrated on a commercial scale and therefore were not selected for testing. Based on technical publications, it is evident that recycling the waste back into the electric furnace has been attempted on a limited basis, and is a waste minimization technique that reduces the amount of waste requiring land disposal. The Agency encourages recycling and waste minimization practices, however, they cannot be required because process changes may be necessary. Several different strategies for direct recycle of K061 to steel production have been studied. Additionally, some recycle technologies utilize high temperature processing to prepare the material to be reintroduced to the electric furnace for reuse.

The dust may be directly injected back into the furnace or it may be pelletized or briquetted to improve handling. This step may involve the addition of water and binders to improve the strength of the pellets or briquettes. The resulting aggregate may be directly inserted into the electric furnace, or processed by high temperature roasting or sintering to improve the strength and composition of the pellets/briquettes. Recycling the waste facilitates recovery of the iron and calcium for reuse in steel making, while the volatile metals (zinc) are enriched in the dust to the air pollution control systems. The enriched zinc dust may be periodically purged from the system and sold as K061 to zinc smelters.

A process related to both direct recycle of pelletized dust and high temperature metals recovery involves high temperature reduction of pelletized dust to yield metallized iron pellets for use in cupola, blast, or electric furnaces and a zinc dust for zinc smelters. This process has not been demonstrated on a commercial scale for K061. Another process which has not been demonstrated involves the recycle of K061 as an additive to fluxes in steel production.

Hydrometallurgical extraction techniques may be applicable to K061. These techniques involve leaching metals from the dust using acidic, caustic, or special solutions, and then recovering metals from solution by precipitation and/or electrolysis. The volume of residual to be land disposed is also reduced. Hydrometallurgical technologies have limited applicability because of their lack of selectivity for leaching specific metals, however, and therefore, have not been developed on a commercial scale.

The Agency does not believe that other technologies are applicable because various physical and chemical characteristics of the waste would not allow treatment. For example, chemical precipitation cannot be used for this waste because the metals are already in solid form and therefore are not amenable to precipitation. Similarly, physical separation of metal constituents by centrifugation or magnetic separation does not appear to be applicable because of the size, weight, and composition of the various metal particles.

4. IDENTIFICATION OF BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT) FOR K061

4.1 Introduction

In this section, EPA explains its analyses for determining which of the demonstrated technologies provides the best level of treatment and also complies with the Agency's criteria for "available". As explained in Section 1, a determination of "best" will generally involve a statistical comparison of performance data from each of the demonstrated treatment technologies; the statistical method used is the analysis of variance (ANOVA) and is described in Appendix A of this document.

As discussed in Section 3, the demonstrated treatment technologies for K061 are high temperature metals recovery and stabilization. The Agency collected performance data for these treatment technologies from field testing, review of literature sources, and data submitted by industry. Performance data consists of 55 data sets for the treatment of K061 by high temperature metals recovery and stabilization. (A data set consists of paired untreated and treated waste analytical data). Specifically, the Agency has collected 15 data sets for high temperature metals recovery (7 for rotary kiln, 2 for plasma arc reactor, 3 for rotary kiln/electric furnace, 2 for molten slag reactor and 1 for flame reactor). 40 data sets for stabilization of K061 were also collected.

4.2 Data Screening

As discussed in Section 1, in cases where EPA has data from more than one technology, the Agency first screens the data to ensure performance

comparisons are made on data of comparable quality. Screening criteria include the design and operating parameters associated with the treated data, the type of analytical testing (i.e., total waste concentration, EP, or TCLP), and finally, quality control/quality assurance analyses. Below is a discussion of the results of applying the above screening criteria to the 15 data sets for high temperature metal recovery and the 40 data sets for stabilization.

Fifteen data sets were considered in the development of BDAT for high temperature metals recovery. Twelve of these data sets were deleted because they did not meet the requirements of the BDAT program. For the rotary kiln process, 4 of the 7 data sets were deleted due to poor operation of the treatment system during the time data were being collected.

The two data sets from the plasma arc reactor system were deleted for several reasons. The first set was deleted because the data did not include TCLP analysis for the treated residual, and analytical quality assurance/quality control data were incomplete. For the second data set, the analytical testing was also incomplete as were the quality assurance quality control data. Additionally, insufficient design and operating data were submitted. Therefore, these data could not be used to assess the treatment performance of the plasma arc reactor sytem.

The three data sets for the rotary hearth/electric furnace system included incomplete analytical results, and did not contain design and operating data or quality assurance/quality control analyses.

Specifically, only TCLP analyses for the untreated and treated waste were performed. In addition, analyses were only provided for a limited number of BDAT list metal constituents. These data were not sufficient for the Agency to assess treatment performance.

The two data sets for the molten slag reactor were not used to determine BDAT because the data collected did not include complete analytical testing and analytical quality assurance/quality control analyses. These data only included total waste concentration and EP Toxicity analysis for the untreated and treated waste. Additionally, no design and operating data were included.

One data set for the flame reactor system was collected. These data included limited analytical testing (total concentration for only four constituents and no TCLP analyses). Additionally, the design and operating data collected were inadequate to evaluate treatment performance so these data were deleted from consideration.

For stabilization of K061, 40 data sets were collected. Thirty-one of these data sets were deleted for the following reasons. For twenty one data sets collected from one facility, only EP Toxicity analyses were performed on the stabilized waste and was only performed for cadmium, chromium, and lead. Additionally, no design and operating data and quality assurance/quality control data were submitted. Ten data sets collected from another facility were also deleted because they only contained EP Toxicity data for the untreated and treated wastes and contained no quality assurance/quality control or design and operating data.

Nine data sets for stabilization using three different binding agents: cement, kiln dust, and lime/fly ash, met the requirements of the program. The design and operating data collected during testing did not indicate that the system was poorly designed or poorly operated. Therefore, these data sets were used to determine the best demonstrated available technology for K061.

4.3 Data Accuracy

After the screening tests, EPA adjusted the remaining analytical data based on the analytical recovery values in order to take into account analytical interferences associated with the chemical makeup of the treated sample. In developing recovery data (also referred to as accuracy data), EPA first analyzed a waste for a constituent and then added a known amount of the same constituent (i.e., spike) to the waste material. The total amount recovered after spiking minus the initial concentration in the sample divided by the amount added is the recovery value. The analytical data used to identify BDAT were adjusted for accuracy using the lowest recovery value for each constituent. This adjustment ensures that treatment data from high temperature metals recovery and stabilization can be compared on an equal basis.

4.4 Analysis of Variance

Following accuracy adjustments of the performance data remaining after the screening process, EPA then compared the performance data using the ANOVA to determine which, if any, of the two demonstrated technologies provides the best treatment. As mentioned, these technologies are high temperature metal recovery and stabilization. For K061, performance was

compared from two standpoints: 1) the total composition of the BDAT list metals remaining after treatment and 2) the amount of metal found in the leachate from the TCLP.

Relative to the first criteria, high temperature metal recovery was clearly better in that stabilization is not meant to reduce the amount of a constituent present but rather minimize the amount that can be leached. Accordingly, the Agency did not perform any statistical analysis comparing the performance of these technologies on a total constituent basis.

Relative to the TCLP, the Agency compared the leachate concentrations of the following BDAT list metals following high temperature metals recovery and stabilization. Prior to this comparison, EPA examined the 3 types of stabilization that use different binding agents: cement, kiln dust, and lime/fly ash to determine which type provides the "best" stabilization treatment. The best stabilization was determined to be lime/fly ash. A comparison of lime/fly ash stabilization to high temperature metals recovery was made based on the TCLP values of the following BDAT list metals: cadmium, chromium, lead, mercury, and zinc. The treated values for these metals achieved by high temperature metals recovery and stabilization are shown in Table 4-1.

The results of the ANOVA test are presented in Appendix D. They indicate that high temperature metals recovery provides significantly better treatment for lead and zinc and equivalent (i.e., no significant difference in treatment performance) treatment for cadmium, chromium, and

Table 4-1 Data for ANOVA Between High Temperature Metals Recovery and Stabilization (Accuracy Corrected Values)

	High Temperature Metals Recovery Treated Waste (mg/l)				Stabilization (Lime/Fly Ash) Treated Waste (mg/l)		
Constituent	SS #3	SS #4	SS #7	Constituent	SS #7	SS #8	SS #9
Cd (TCLP)	<0.069	<0.069	<0.069	Cd (TCLP)	0.036	0.053	0.080
Cr (TCLP)	<0 118	<0.118	<0 118	Cr (TCLP)	0.113	0.087	0.065
Pb (TCLP)	<0 033	<0.033	<0.033	Pb (TCLP)	0.140	0.064	0.061
Hg (TCLP)	<0 0002	0 0030	<0 0002	Hg (TCLP)	0.0015	0.0015	0.0016
Zn (TCLP)	0 246	0.131	0.0820	Zn (TCLP)	0.681	0.206	0.458

Reference 20 - Onsite Engineering Report for Horsehead Resource Development Co., Inc.

Reference 21 - Onsite Engineering Report for Waterways Experiment Station for K061

mercury; accordingly, high temperature metal recovery is also "best" relative to the amount of BDAT list metals found in the leachate from the TCLP value.

In addition to being "best" and "demonstrated", high temperature metals recovery also complies with the criteria for "available". High temperature metals recovery is commercially available or can be purchased from a proprietor, and high temperature metals recovery provides substantial reduction of the concentration of BDAT list metal constituents. Because EPA has determined that this technology is "best", "demonstrated", and "available", high temperature metal recovery is the technology basis for treatment standards for K061.

In addition to being the best technology, high temperature metals recovery provides for resource recovery and reduction in volume of the residual to be land disposed. The Agency believes that establishing recovery as the best demonstrated available technology is consistent with the national policy identified in HSWA by which Congress set up a hierarchy of waste management alternatives. The hierarchy places source reduction as the first priority of waste management, with recycling as the second, treatment as the next, and land disposal as the last.

5. SELECTION OF REGULATED CONSTITUENTS

As discussed in Section 1, the Agency has developed a list of hazardous constituents (Table 1-1) from which the constituents to be regulated are selected. The list is a "growing list" that does not preclude the addition of new constituents as additional key data and information become available. The list is divided into the following nine categories: volatile organics, semivolatile organics, metals, inorganics other than metals, organochlorine pesticides, phenoxyacetic acid herbicides, organophosphorous pesticides, PCBs, and dioxins and furans. Also discussed in Section 1 is EPA's process for selecting constituents to regulate. In general, this process consists of identifying constituents in the untreated waste that are present at treatable concentrations and then regulating the constituents in that group necessary to ensure effective treatment. Below is a discussion that details how EPA arrived at the list of constituents to be regulated for K061.

Of the 232 constituents on the BDAT list, EPA analyzed for 153 organics, 15 metals, and 3 inorganic compounds. Forty-two constituents, including organochlorine pesticides, phenoxyacetic acid herbicides, organophosphorus insecticides, PCBs, and dioxins and furans, were not analyzed because they have a very low probability of being found in the waste. In addition, eighteen constituents have been added to the BDAT list since the time of sampling and therefore, were not analyzed, such as hexavalent chromium and xylenes. EPA's analysis showed that five

organics and fifteen BDAT list metals were present. (Table 5-1 shows the specific constituents that were analyzed and detected in the K061 waste.) Of the one volatile and four semivolatile BDAT list organics detected in the untreated waste, none were present at treatable concentrations. Of the 15 BDAT list metals, only five were determined to be present at levels that could be treated using the rotary kiln process for high temperature metals recovery. These metals are cadmium, chromium, lead, mercury, and zinc.

Table 5-2 presents the three data sets representing a well-operated rotary kiln high temperature metals recovery system for these five constituents. EPA is regulating all of these metals both with regard to the total concentration and the concentration of the metals in the leachate from the TCLP. The total constituent concentration is being used because the underlying principle of metals recovery is the reduction of the amount of metals in the waste by separating the metals for recovery; therefore, total constituent concentration in the treated residual is an important measure of performance for high temperature metals recovery. Additionally, EPA believes it is important that any remaining metal in a treated residual not be in a state that is easily leachable; accordingly, EPA is using the TCLP as the measure of performance.

Table 5-1 BDAT List of Constituents-Detection Limits for Untreated K061

BDAT Constituents	Units	D = Detected ND = Not Detected NA = Not Analyzed	Detection Limit
Volatile Organic Compounds			
Acetonitrile	ppb	ND	100
Acrolein	ppb	ND	100
Acrylonitrile	ppb	ND	100
Benzene	ppb	ND	5
Bromodichloromethane	ppb	ND	5
Bromomethane	ppb	ND	10
Carbon Tetrachloride	ppb	ND	5
Carbon disulfide	ppb	ND	5
Chlorobenzene	ppb	ND	5
2 Chloro-1,3-butadiene	ppb	ND	100
Chlorodibromomethane	ppb	ND	5
Chloroethane	ppb	ND	10
2-Chloroethyl vinyl ether	ppb	ND	10
Chloroform	ppb	ND	5
Chloromethane	ppb	ND	10
3-Chloropropene	ppb	ND	100
1,2-Dibromo-3-chloropropane	ppb	ND	10
1,2-Dibromoethane	ppb	ND	5
Dibromomethane	ppb	ND	5
Trans-1,4-Dichloro-2-butene	ppb	ND	100
Dichlorodifluoromethane	ppb	ND	10
1,1-Dichloroethane	ppb	ND	5
1,2-Dichloroethane	ppb	ND	5
1,1-Dichloroethylene	ppb	ND	5
Trans-1,2-Dichloroethene	ppb	ND	5
1,2-Dichloropropane	ppb	ND	5
Trans-1,3-Dichloropropene	ppb	ND	5
cis-1,3-Dichloropropene	ppb	ND	5
1,4-Dioxane	ppb	ND	200
Ethyl cyanide	ppb	ND	100
Ethyl methacrylate	ppb	ND	100
Iodomethane	ppb	ND	50
Isobutyl alcohol	ppb	ND	200
Methyl ethyl ketone	ppb	ND	10
Methyl methacrylate	ppb	ND	100
Methyl methanesulfonate	ppb	ND	200

Table 5-1 (Continued)

BDAT Constituents	Units	D = Detected ND = Not Detected NA = Not Analyzed	Detection Limit*
Volatile Organic Compounds (continued)			
Methylacrylonitrile	ppb	ND	100
Methylene chloride	ppb	ND	5
Pyridine	ppb	ND	400
1,1,1,2-Tetrachloroethane	ppb	ND	5
1,1,2,2-Tetrachloroethane	ppb	ND	5
Tetrachloroethene	ppb	D	5
Toluene	ppb	ND	5
Tribromomethane	ppb	ND	5
1,1,1-Trichloroethane	ppb	ND	5
1,1,2-Trichloroethane	ppb	ND	5
Trichloroethene	ppb	ND	5
Trichloromonofluoromethane	ppb	ND	5
1,2,3-Trichloropropane	ppb	ND	5
Vinyl chloride	ppb	ND	10
Semivolatile Organic Compounds			
Acenaphthalene	ppb	ND	400
Acenaphthene	ppb	ND	400
Acetophenone	ppb	ND	800
2-Acetylaminofluorene	ppb	ND	800
4-Aminobiphenyl	ppb	ND	800
Aniline	ppb	ND	400
Anthracene	ppb	ND	400
Aramite	ppb	ND	NA

*NA = No detection limit available

Table 5-1 (Continued)

EDAT Constituents	Units	D = Detected ND = Not Detected NA = Not Analyzed	Detection Limit
Semivolatile Organic Compounds (continued)			
Benz(a)anthracene	ppb	ND	400
Benzenethiol	ppb	ND	-
Benzidine	ppb	ND	2,000
Benzo(a)pyrene	ppb	ND	400
Benzo(b)fluoranthene	ppb	D	400
Benzo(ghi)perylene	ppb	ND	400
Benzo(k)fluoranthene	ppb	ND	400
p-Benzoquinone	ppb	ND	-
Bis(2-chloroethoxy)ethane	ppb	ND	400
Bis(2-chloroethyl)ether	ppb	ND	400
Bis(2-chloroisopropyl)ether	ppb	ND	400
Bis(2-ethylhexyl)phthalate	ppb	D	400
4-Bromophenyl phenyl ether	ppb	ND	400
Butyl benzyl phthalate	ppb	ND	400
2-sec-Butyl-4,6-dinitrophenol	ppb	ND	200
p-Chloroaniline	ppb	ND	400
Chlorobenzilate	ppb	ND	NA
p-Chloro-m-cresol	ppb	ND	400
2-Chloronaphthalene	ppb	ND	400
2-Chlorophenol	ppb	ND	400
3-Chloropropionitrile	ppb	ND	NA
Chrysene	ppb	D	400
ortho-Cresol	ppb	ND	400
para-Cresol	ppb	ND	400
Dibenz(a,h)anthracene	ppb	ND	400
Dibenzo(a,e)pyrene	ppb	ND	NS
Dibenzo(a,i)pyrene	ppb	ND	NA
m-Dichlorobenzene	ppb	ND	400
o-Dichlorobenzene	ppb	ND	400
p-Dichlorobenzene	ppb	ND	400

NA = No detection limit available
NS = No standards available.
- = Not detected, estimated detection liaison has not been established.

Table 5-1 (Continued)

BOAT Constituents	Units	D = Detected ND = Not Detected NA = Not Analyzed	Detection Limit*
Semivolatile Organic Compounds (continued)			
3,3'-Dichlorobenzidine	ppb	ND	800
2,4-Dichlorophenol	ppb	ND	400
2,6-Dichlorophenol	ppb	ND	400
Diethyl phthalate	ppb	ND	400
3,3'-Dimethoxybenzidine	ppb	ND	400
p-Dimethylaminoazobenzene	ppb	ND	800
3,3'-Dimethylbenzidine	ppb	ND	NA
2,4-Dimethylphenol	ppb	ND	400
Dimethyl phthalate	ppb	ND	400
Di-n-butyl phthalate	ppb	ND	400
1,4-Dinitrobenzene	ppb	ND	2,000
4,6-Dinitro-o-cresol	ppb	ND	1,980
2,4-Dinitrophenol	ppb	ND	1,980
2,4-Dinitrotoluene	ppb	ND	400
2,6-Dinitrotoluene	ppb	ND	400
Di-n-octyl phthalate	ppb	ND	400
Di-n-propylnitrosamine	ppb	ND	400
1,2-Diphenylhydrazine	ppb	ND	2,000
Fluoranthene	ppb	D	400
Fluorene	ppb	ND	400
Hexachlorobenzene	ppb	ND	400
Hexachlorobutadiene	ppb	ND	400
Hexachlorocyclopentadiene	ppb	ND	400
Hexachloroethane	ppb	ND	400
Hexachlorophene	ppb	ND	NA
Hexachloropropene	ppb	ND	ND
Indeno(1,2,3-cd)pyrene	ppb	ND	400
Isosafrole	ppb	ND	800
Methapyrilene	ppb	ND	NS

*NA = No detection limit available.
NS = No standard available.

Table 5-1 (Continued)

BDAT Constituents	Units	D = Detected ND = Not Detected NA = Not Analyzed	Detection Limit*
Semivolatile Organic Compounds (continued)			
3-Methylcholanthrene	ppb	ND	800
4,4'-Methylenebis (2-chloroaniline)	ppb	ND	800
Naphthalene	ppb	ND	400
1,4-Naphthoquinone	ppb	ND	NA
1-Naphthylamine	ppb	ND	2,000
2-Naphthylamine	ppb	ND	2,000
p-Nitroaniline	ppb	ND	1,980
Nitrobenzene	ppb	ND	400
4-Nitrophenol	ppb	ND	1,980
N-Nitrosodi-n-butylamine	ppb	ND	-
N-Nitrosodiethylamine	ppb	ND	400
N-Nitrosodimethylamine	ppb	ND	400
N-Nitrosomethylethylamine	ppb	ND	400
N-Nitrosomorpholine	ppb	ND	800
N-Nitrosopiperidine	ppb	ND	400
n-Nitrosopyrrolidine	ppb	ND	2,000
5-Nitro-o-toluidine	ppb	ND	800
Pentachlorobenzene	ppb	ND	-
Pentachloroethane	ppb	ND	NA
Pentachloronitrobenzene	ppb	ND	4,000
Pentachlorophenol	ppb	ND	1,980
Phenacetin	ppb	ND	800
Phenanthrene	ppb	ND	400
Phenol	ppb	ND	400
2-Picoline	ppb	ND	400
Pronamide	ppb	ND	-
Pyrene	ppb	ND	400
Resorcinol	ppb	ND	NA
Safrole	ppb	ND	2,000

*NA = No detection limit available
- = Not detected, estimated detection limit has not been established

Table 5-1 (Continued)

BDAT Constituents	Units	D = Detected ND = Not Detected NA = Not Analyzed	Detection Limit
Semivolatile Organic Compounds (continued)			
1,2,4,5-Tetrachlorobenzene	ppb	ND	800
2,3,4,6-Tetrachlorophenol	ppb	ND	-
1,2,4-Trichlorobenzene	ppb	ND	400
2,4,5-Trichlorophenol	ppb	ND	1,980
2,4,6-Trichlorophenol	ppb	ND	400
Tris(2,3-dibromopropyl) phosphate	ppb	ND	-
Metals[1]			
Antimony		D	
Arsenic		D	
Barium		D	
Beryllium		D	
Cadmium		D	
Chromium (total)		D	
Copper		D	
Lead		D	
Mercury		D	
Nickel		D	
Selenium		D	
Silver		D	
Thallium		D	
Vanadium		D	
Zinc		D	
Inorganics			
Cyanide		D	1
Fluoride		D	70.4
Sulfide		D	5.6
Organochlorine Pesticides			
Aldrin		NA	
alpha-BHC		NA	
beta-BHC		NA	
delta-BHC		NA	

[1]All BDAT list metals were detected at concentrations above the detection limits

Table 5-1 (Continued)

BDAT Constituents	Units	D = Detected ND = Not Detected NA = Not Analyzed	Detection Limit
Organochlorine Pesticides (continued)			
gamma-BHC		NA	
Chlordane		NA	
DDD		NA	
DDE		NA	
DDT		NA	
Dieldrin		NA	
Endosulfan I		NA	
Endosulfan II		NA	
Endrin		NA	
Endrin aldehyde		NA	
Heptachlor		NA	
Heptachlor epoxide		NA	
Isodrin		NA	
Kepone		NA	
Methoxychlor		NA	
Toxaphene		NA	
Phenoxyacetic Acid Herbicides			
2,4-Dichlorophenoxyacetic acid		NA	
Silvex		NA	
2,4,5-T		NA	
Organophosphorous Insecticides			
Disulfoton		NA	
Famphur		NA	
Methyl parathion		NA	
Parathion		NA	
Phorate		NA	
PCBs			
Aroclor 1016		NA	
Aroclor 1221		NA	
Aroclor 1232		NA	
Aroclor 1242		NA	
Aroclor 1248		NA	
Aroclor 1254		NA	
Aroclor 1260		NA	

Table 5-1 (Continued)

BDAT Constituents	Units	D = Detected ND = Not Detected NA = Not Analyzed	Detection Limit*
Dioxins and Furans			
Hexachlorodibenzo-p-dioxins		NA	
Hexachlorodibenzofurans		NA	
Pentachlorodibenzo-p-dioxins		NA	
Pentachlorodibenzofurans		NA	
Tetrachlorodibenzo-p-dioxins		NA	
Tetrachlorodibenzofurans		NA	
2,3,7,8-Tetrachlorodibenzo-p-dioxin		NA	

Table 5-2 Regulated Constituent Reduction by High Temperature Metals Recovery (Rotary Kiln) - Range of 3 Data Sets EPA Collected Data (Treated Values are Accuracy Corrected Values)

Constituent	Untreated Waste (ppm)	Treated Waste (ppm)	TCLP Treated Waste (mg/l)
Cadmium	394 - 800	<15.6	<0.069
Chromium	903 - 1,190	500 - 1,027	<0.118
Lead	15,500 - 20,800	569 - 3,697	<0.33
Mercury	1.0 - 1.6	<0.1	<0.0002 - 0.0030
Zinc	135,000 - 155,000	5,369 - 13,216	0.0820 - 0.246

Reference 20 - Onsite Engineering Report for Horsehead Resource and Development Co., Inc.

6. CALCULATION OF BDAT TREATMENT STANDARDS

This Section presents the calculation of treatment standards for K061. Details of the methodology are provided in Section 1 and in the "Generic Quality Assurance Project Plan (QAPP) for the Land Disposal Restriction Program (BDAT)," March, 1987. As discussed in Section 5, the BDAT treatment standards are proposed for the regulated constituents cadmium, chromium, lead, mercury, and zinc. These standands are based on treatment performance data collected by the Agency for the rotary kiln process for high temperature metals recovery. As presented in Section 4, several data sets submitted by industry could not be used because they did not contain sufficient analytical data to evaluate the system. In addition, many of these data sets also lacked design and operating data and quality assurance/quality control data. Also presented in Section 4 was the Agency's methodology for determining that the rotary kiln process for high temprature metals recovery provides better treatment than stabilization. Treatment standards for K061 are being proposed for both total concentration and the TCLP leachate from the nonwastewater residuals.

The BDAT treatment standards (1) are reflective of treatment data from a well designed and well operated treatment system, (2) account for analytical uncertainty, and (3) account for variability resulting from treatment, sampling, and analytical techniques and procedures.

The BDAT treatment standards for K061 were developed following the following methodology.

6.1 Screening of Data

As the first step in the development of BDAT treatment standards, EPA screened the available treatment performance data with regard to three criteria: (1) design and operation, (2) quality assurance/quality control analyses and (3) the analytical tests used to assess performance.

The performance data collected for treatment of K061 were screened for completeness with regard to design and operating data, quality assurance/quality control analyses, and analytical testing used. A complete data set consists of paired untreated and treated waste analyses for BDAT metals, including total concentration and TCLP extract analyses for the treated residual, design and operating data, and quality assurance/quality analyses. For high temperature metals recovery, treatment performance is judged on both total constituent reduction and the leachability of the treated residuals, as measured by TCLP. For stabilization, which is used to reduce the leachability of metals, the Agency is using the TCLP as the measure of performance. Several data sets collected did not contain the required data to evaluate the treatment performance, and threfore were not used to determine BDAT.

As described in Section 4, four of the seven data sets for high temperature metals recovery (rotary kiln process) were deleted due to poor operation of the treatment system during the time data were being collected. Nine data sets for stabilization using three different

binding agents: cement, kiln dust, and lime/fly ash, contained all of the required data elements. The design and operating data collected during stabilization testing did not indicate that the system was poorly designed or operated.

Following these data screening procedures, the performance data for high temperature metals recovery were compared to stabilization using the analysis of variance test (ANOVA) to determine which technology provides the best treatment for the regulated constituents cadmium, chromium, lead, mercury, and zinc.

As presented in Section 4, the ANOVA was performed on 3 data sets for high temperature metals recovery (rotary kiln process) and 3 data sets from lime/fly ash stabilization. The comparison was performed on accuracy corrected values for the regulated constituents to account for analytical variability. High temperature metals recovery was identified as the "best" treatment technology for K061 based on the ANOVA using these accuracy corrected performance data.

6.2 Correction of Analytical Data

The analytical data used to select BDAT and calculate treatment standards are adjusted in order to take into account analytical interferences associated with the chemical composition of the sample. Because of the concentration of the various constituents of the residual slag, the detection limits attainable for lead, cadmium, and chromium for

both total treated concentration and TCLP, varied due to interferences. Generally, where this occurred, we selected the highest detection limit measured to develop treatment standards because the low detection limits may not be consistently achievable.

The treated analytical data are corrected for accuracy by multiplying the raw data by a correction factor. The correction factors are calculated based on the matrix spike recoveries performed for each regulated constituent (total concentration and TCLP). Additionally, two matrix spike recoveries are performed for each constituent, and the lowest value is used to calculate the correction factor. As a result, the correction factor used to develop treatment standards is conservative to account for analytical variability and uncertainty. The correction factors are calculated by dividing the lowest recovery into 100 to provide the most conservative correction factor. The matrix spike recoveries and accuracy correction factors for total concentration for high temperature metals recovery are presented in Table 6-1. The matrix spike recoveries and accuracy correction factors for TCLP extracts for high temperature metals recovery are presented in Table 6-2. Table 6-3 presents the percent recoveries and correction factors for the TCLP extracts for stabilization.

The accuracy corrected data were calculated by multiplying the analytical value by the correction factor. If a regulated constituent

Table 6-1 Matrix Spike Recoveries for Treated Waste Total Concentrations and Accuracy Correction Factors for High Temperature Metals Recovery

BDAT constituent	Original amount found (mg/kg)	Sample			Sample duplicate			Correction Factor
		Spike added (mg/kg)	Spike result (mg/kg)	Percent recovery*	Spike added (mg/kg)	Spike result (mg/kg)	Percent recovery*	
Cadmium	<1.5	2 5	<1.5	NC	2 5	2 4	96	1 04
Chromium	978	2,000	2,970	100	2,000	2,870	95	1 05
Lead	365	500	683	64	500	705	68	1.56
Mercury	<0.1	0.5	0.5	100	0.5	0 5	100	1.00
Zinc	4,680	6,000	9,770	85	6,000	9,950	88	1 18

NC = Not Calculatable.

*Percent Recovery = [(Spike Result - Original Amount)/Spike Added] x 100.

Reference 20 - Onsite Engineering Report for Horsehead Resource Development Co., Inc.

Table 6-2 Matrix Spike Recovery for TCLP Extract for Treated Waste and Accuracy Correction Factors for High Temperature Metals Recovery

BDAT constituent	Original sample (ug/l)	Sample			Sample duplicate		Correction Factor
		Spike added (ug/l)	Spike result (ug/l)	Percent recovery*	Spike result (ug/l)	Percent recovery*	
Cadmium	4 2	25	26	87	27	91	1 15
Chromium	<4 0	50	35	70	34	68	1 47
Lead	<5 0	25	22	88	19	76	1 32
Mercury	<0 2	1.0	0.9	90	1 1	110	1 11
Zinc	2,640	10,000	12,600	100	12,400	98	1 02

Percent Recovery = [(Spike Result - Original Amount)/Spike Added] 100

Reference 20 - Onsite Engineering Report for Horsehead Resource Development Co., Inc.

Table 6-3 Matrix Spike Recoveries and Accuracy Correction Factors for the TCLP Extracts from Stabilization

BDAT Regulated Constituent	Original amount found (ug/l)	Amount spiked (ug/l)	Lime/Flyash Amount recovered (ug/l)	Lime/Flyash Percent recovery*	Lime/Flyash Amount recovered (ug/l)	Lime/Flyash Percent recovery*	Correction Factor
Cadmium	34	100	123	92	122	91	1.09
Chromium	71	100	140	82	142	83	1.22
Lead	71	50	131	108	138	114	0.93
Mercury	1 4	3	5.3	120	4.8	110	0.91
Zinc	226	500	690	95	632	87	1.15

Percent Recovery = [(Spike Result - Original Amount)/Spike] 100.

Reference 21 - Onsite Engineering Report for Waterways Experiment Station for K061

was not detected in the treated waste, the corrected value was calculated by multiplying the detection limit of that constituent by the correction factor. These accuracy corrected data are then used to evaluate the treatment standard by multiplying the average treated concentration by a variability factor.

6.3 Calculation of Variability Factors and Treatment Standards

The treatment standards for each regulated constituent (total concentration and TCLP) are calculated by multiplying the average treated concentration by the appropriate variability factor. For each regulated constituent, average treated concentrations and variability factors were calculated for both total concentration and TCLP extract. Because the treatment standards are based on high temperature metals recovery and the performance is evaluated by both constituent reduction and leachability of the residual as measured by TCLP, the variability factors are calculated for both parameters.

The variability factor represents a variability inherant in the treatment process and the sampling and analytical methods. Variability factors are determined by statistically calculating the variability seen for a number of data points for each regulated constituent (total concentration and TCLP).

The variability factors were calculated for both total concentration and TCLP extract for the five regulated constituents. These variability

factors were calculated based on the logarithmic concentration values of the regulated constituents in the treated residual (total concentration and TCLP), their logarithmic mean and their logarithmic standard deviation. A detailed description of the variability factor calculation is presented in Appendix A. For regulated constituents not detected in the treated waste in all data sets used for regulation, a variability factor of 2.8 was used. The rationale and methodology used to calculate this variability factor is presented in Section 1, as well as in Appendix A.

The treatment standards were calculated by multiplying the average treated concentration (total concentration and TCLP) by the corresponding variability factor. This calculation is presented in Table 6-4.

The BDAT treatment standards for K061 are proposed for both total concentration and the leachability of the residual as measured by the TCLP and are as follows:

Constituent	Total Concentration (mg/kg)	TCLP Concentration (mg/l)
Cadmium	44	0.19
Chromium	1,730	0.33
Lead	20,300	0.09
Mercury	0.28	0.02
Zinc	24,100	0.50

Table 6-4 Variability Factors and Calculated Treatment Standards for K061

Regulated Constituent	Untreated Total Concentration Range for SS #3,#4,#7 (ppm)	Accuracy Adjusted Treated Concentration: Sample Set #3	Sample Set #4	Sample Set #7	Average Treated Concentration (mg/kg)/(mg/l)	Variability* Factor	Average xVF	Treatment Standard (mg/kg)/(mg/l)
Cadmium								
Residual	290 to 808	<15.6	<15 6	<15 6	15 6	2.8	43 7	44
Residual TCLP		<0 069	<0 069	<0.069	0 069	2 8	0 193	0 19
Chromium								
Residual	903 to 1,190	785	1,027	500	771	2.24	1,727	1,730
Residual-TCLP		<0 118	<0 118	<0.118	0 118	2.8	0 330	0 33
Lead								
Residual	15,500 to 20,600	3,026	569	3,697	2,431	8.35	20,296	20,300
Residual-TCLP		<0 033	<0 033	<0.033	0 033	2.8	0 092	0.09
Mercury								
Residual	1.0 to 1 6	<0 1	<0 1	<0.1	0 10	2 8	0 28	0 28
Residual-TCLP		<0 0002	0.0030	<0.0002	0 0011	17 13	0 019	0 02
Zinc								
Residual	135,000 to 155,000	13,216	5,522	5,369	8,036	3.00	24,107	24,100
Residual-TCLP		0.246	0 131	0.082	0 153	3.28	0 502	0.50

*For constituents having values at the detection limit, a variability factor of 2.8 was used.
See Appendix D for the rationale

7. CONCLUSIONS

The Agency has proposed treatment standards for the listed waste K061 from the iron and steel industry. The treatment standards presented in Table 7-1 are established for total concentration and TCLP leachate of non-wastewater residuals. The treatment standards proposed for K061 have been developed consistent with EPA's promulgated methodology for BDAT (November 7, 1986, 51 FR 40572).

The waste K061 is generated in the primary production of steel in electric furnaces. This waste is primarily comprised of metals, inorganics, and water. Although the concentrations of specific constituents will vary from facility to facility, all of the wastes are expected to contain concentrations of BDAT list metals, high filterable solids contents, and low to moderate water content, and are expected to be treatable to the same levels using the same technology.

All BDAT list metal constituents are generally present in the waste, but in varying concentrations. As a result, to reduce the monitoring burden on treaters, the Agency has developed the treatment standard based on five BDAT list metals that are generally found in the highest concentrations in K061 wastes.

Through available data bases, EPA's technology testing program, and data submitted by industry, the Agency has identified two demonstrated treatment technologies for treatment of BDAT list metals present in the waste. The demonstrated treatment technologies for K061 are high

Table 7-1 BDAT Treatment Standards for K061*
(As Concentration in Nonwastewater Treatment Residual)

Constituent	Total Concentration (mg/kg)	TCLP Concentration (mg/l)
Cadmium	44	0.19
Chromium	1,730	0.33
Lead	20,300	0.09
Mercury	0.28	0.02
Zinc	24,100	0.50

*Both total concentration and TCLP concentration values must be complied with prior to land disposal.

temperature metals recovery and stabilization. As discussed in Section 3, several high temperature metals recovery systems have been demonstrated for K061: rotary kiln process, rotary hearth/electric furnace, plasma arc reactor, molten slag reactor, and flame reactor. Stabilization is demonstrated for treatment of K061 by the reduction of the leachability of BDAT list metals in the treated waste. Other technologies are potentially applicable for treatment of K061 including hydrometallurgical extraction (acid leaching) and recycle.

In the development of treatment standards for K061, the Agency examined all available treatment data. The Agency collected treatment data from literature sources and received industry submitted data. The Agency also conducted tests using high temperature metals recovery and stabilization of K061 waste. The Agency collected 15 data sets for high temperature metals recovery. The 15 data sets consist of seven data sets for the rotary kiln process, two for plasma arc reactor, three for rotary kiln/electric furnace, two for molten slag reactor system and 1 for the flame reactor. The Agency also collected 40 data sets for stabilization of K061. The data consists of 21 data sets from one facility, 10 data sets from another facility and nine data sets collected by Agency testing for three different binders: cement, kiln dust, and lime/fly ash.

Many of the data sets collected did not contain all of the required information needed by the Agency to assess treatment performance (i.e., total concentration and TCLP leachate results), quality assurance/quality control analyses data, design and operating information, and thus they

were deleted from consideration. In addition to the analytical data for the untreated waste and treated residual, design and operating data were collected during the testing of each technology. For high temperature metals recovery, the data collected by the Agency indicated that four of the seven data sets were collected during periods of poor operation of the treatment system. As a result, only three of the data sets from the Agency's testing for high temperature metals recovery met the requirements of the BDAT program.

For stabilization data, the Agency was able to analyze results from the use of three different binders (i.e., cement, kiln dust, and lime/fly ash) on K061 wastes. Data sets for stabilization by lime/fly ash were considered in the development of BDAT based on an analysis of variance (ANOVA) comparison of the three binders.

A statistical comparison of performance data for the two technologies (high temperature metals recovery and stabilization) was performed to identify the "best demonstrated" technology for K061. The analyses of variance test was used to compare the TCLP extract analysis for cadmium, chromium, lead, mercury, and zinc for the two technologies. The results of the test indicated that high temperature metals recovery provides superior performance for lead and zinc and that the two technologies are equivalent (i.e., no significant difference in treatment performance) for cadmium, chromium, and mercury. Additionally, the selection of high temperature metals recovery as BDAT over stabilization is consistent with the Agency's policy to promote reuse/recycling technologies that reduce

the amount of hazardous waste to be land disposed. EPA also determined that high temperature metals recovery is an available technology.

The treatment standards for K061 are based on the treatment data collected by the Agency for high temperature metals recovery by the rotary kiln process.

The regulated constituents were selected based on an evaluation of the BDAT list constituents found in the untreated wastes at treatable concentrations and were reduced in concentration in the treated residual. All available waste characterization data and applicable treatment data consistent with the type and quality of data needed by the Agency for this program were used to make this determination. Five constituents were selected for regulation: cadmium, chromium, lead, mercury, and zinc. The treatment standards for the five regulated constituents were derived after adjustment of laboratory data to account for recoveries of these constituents in the analytical process. Subsequently, the mean of the adjusted data points was multiplied by the appropriate variability factor to derive the standard. The variability factor represents the variability inherent in the treatment process and sampling and analytical methods. Variability factors were determined by statistically calculating the variability observed in a given constituent (total concentration and TCLP) for all data sets used in developing the standand. For constituents for which specific variability factors could not be calculated, a variability factor of 2.8 was used (e.g., when the

treated residual concentration for a particular constituent is below detectable levels for all data sets). The rationale for using this variability factor of 2.8 is presented in Section 1 and Appendix D.

Wastes determined to be K061 may be land disposed if they meet both of the treatment standards at the point of disposal. For K061, the treatment standards are based on both total concentration and TCLP extract. The total constituent concentration is being used because the underlying principle of metals recovery is the reduction of the amount of metals in the waste by separating the metals for recovery; therefore, total constituent concentration in the treated residual is an important measure of performance for high temperature metals recovery. Additionally, EPA believes it is important that any remaining metal in a treated residual not be in a state that is easily leachable; accordingly, we are using the TCLP as the measure of performance.

The BDAT technology upon which the treatment standards are based (high temperature metals recovery) need not be specifically utilized prior to land disposal, provided an alternate technology utilized achieves both standards.

These proposed standards have an effective date of August 8, 1990. This date reflects a two-year nationwide variance to the promulgation date due to the lack of nationwide high temperature metals recovery capacity. A detailed discussion of the Agency's determination that a lack of capacity exists is presented in the Capacity Background Document

which is available in the Administrative Record for the First Sixths' rule.

Consistent with Executive Order 12291, EPA prepared a regulatory impact analysis (RIA) to assess the economic effect of compliance with this proposed rule. The RIA prepared for this proposal rule is available in the Administrative Record for the First Sixth's Rule.

REFERENCES

1. Ajax Floor Products Corp. n.d. Product literature: technical data sheets, Hazardous Waste Disposal System. P.O. Box 161, Great Meadows, N.J. 07838.

2. Austin, G.T. 1984. Shreve's chemical process industries, 5th ed. New York: McGraw-Hill.

3. Bishop, P.L., Ransom, S.B., and Grass, D.L. 1983. Fixation Mechanisms in Solidification/Stabilization of Inorganic Hazardous Wastes. In Proceedings of the 38th Industrial Waste Conference, 10-12 May 1983, at Purdue University, West Lafayette, Indiana.

4. U.S. Bureau of Mines, 1983. Characterization of Steel Making Dusts from Electric Furnaces. (As cited by Summary of Available Waste Composition Data from Review of Literature and Data Bases for Use in Treatment Technology Application and Evaluation for "California List" Waste Streams. Prepared for EPA Office of Solid Waste by Versar, Inc. under Contract No. 68-01-7053, Work Assignment No. 38, April 1986.).

5. Calspan Corporation, 1977. Assessment of Industrial Hazardous Waste Practices in the Metal and Refining Industry. (As cited by Summary of Available Waste Composition Data from Review of Literature and Data Bases for Use in Treatment Technology Application and Evaluation for "California List" Waste Streams. Prepared for EPA Office of Solid Waste by Versar, Inc. under Contract No. 68-01-7053, Work Assignment No. 38, April 1986.).

6. U.S. Department of Commerce. Characterization, Recovery and Recycling of EAF Dust, (by Lehigh University), 1982.

7. Conner, J.R. 1986. Fixation and Solidification of Wastes. Chemical Engineering. Nov. 10, 1986.

8. Cullinane, M.J., Jr., Jones, L.W., and Malone, P.G. 1986. Handbook for stabilization/solidification of hazardous waste. U.S. Army Engineer Waterways Experiment Station. EPA report No. 540/2-86/001. Cincinnati, Ohio: U.S. Environmental Protection Agency.

9. Delisting Petition #0535, Harrison Steel Castings Co., Attica, IN (As cites by Summary of Available Waste Composition Data from Review of Literature and Data Bases for Use in Treatment Technology Application and Evaluation for "California List" Waste Streams. Prepared for EPA Office of Solid Waste by Versar, Inc. under Contract No. 68-01-7053, Work Assignment No. 38, April 1986.).

10. Delisting Petition #0555, U.S. Steel Corp., Chicago, IL. (As cited by Summary of Available Waste Composition Data from Review of Literature and Data Bases for Use in Treatment Technology Application and Evaluation for "California List" Waste Streams. Prepared for EPA Office of Solid Waste by Versar, Inc. under Contract No. 68-01-7053, Work Assignment No. 38, April 1986.).

11. Delisting Petition #0601, Stablex Corp., Rock Hill, SC. (As cited by Summary of Available Waste Composition Data from Review of Literature and Data Bases for Use in Treatment Technology Application and Evaluation for "California List" Waste Streams. Prepared for EPA Office of Solid Waste by Versar, Inc. under Contract No. 68-01-7053, Work Assignment No. 38, April 1986.)

12. Delisting Petition #0210, Marathon Steel Co., Longview, TX. (As cited by Summary of Available Waste Composition Data from Review of Literature and Data Bases for Use in Treatment Technology Application and Evaluation for "California List" Waste Streams. Prepared for EPA Office of Solid Waste by Versar, Inc. under Contract No. 68-01-7053, Work Assignment No. 38, April 1986.).

13. Delisting Petition #0250, McClouth Steel Products Co., Trenton, MI. (As cited by Summary of Available Waste Composition Data from Review of Literature and Data Bases for Use in Treatment Technology Application and Evaluation for "California List" Waste Streams. Prepared for EPA Office of Solid Waste by Versar, Inc. under Contract No. 68-01-7053, Work Assignment No. 38, April 1986.).

14. Delisting Petition #0443, Raritan River Steel, Perth Amboy, NJ. (As cited by Summary of Available Waste Composition Data from Review of Literature and Data Bases for Use in Treatment Technology Application and Evaluation for "California List" Waste Streams. Prepared for EPA Office of Solid Waste by Versar, Inc. under Contract No. 68-01-7053, Work Assignment No. 38, April 1986.).

15. Delisting Petition #0617, Bethlehem Steel, Steelton, PA. (Industry Submitted Data)

16. Duby, Paul. 1980. Extractive metallurgy, In Kirk-Othmer encyclopedia of chemical technology. Vol. 9, p. 741.

17. Electric Power Research Institute. 1980. FGD sludge disposal manual, 2nd ed. Prepared by Michael Baker Jr., Inc. EPRI CS-1515 Project 1685-1 Palo Alto, California: Electric Power Research Institute.

REFERENCES (continued)

18. U.S. Environmental Protection Agency. Background Listing Document, November 14, 1980.

19. U.S. Environmental Protection Agency. Engineering Analysis of the Production of Electric Arc Furnace Steel, Draft Report, 1987.

20. U.S. Environmental Protection Agency. Onsite Engineering Report for Horsehead Resource Development Company for K061, Draft Report, 1987.

21. U.S. Environmental Protection Agency. Onsite Engineering Report for Waterways Experiment Station for K061, Draft Report, 1988.

22. U.S. Environmental Protection Agency. U.S. Army Engineer Waterways Experiment Station. Guide to the disposal of chemically stabilized and solidified waste. Prepared for MERL/ORD under Interagency Agreement No. EPA-IAG-D4-0569. PB81-181505. Cincinnati, Ohio.

23. Description of INMETCO's Operations and Identification of the Materials that it Processes (Industry Submitted Data).

24. Lloyd, Thomas. 1980. Zinc compounds. Kirk-Othmer Encyclopedia of Chemical Technology, 3rd. ed. Vol. 24, p. 856.

25. Lloyd, Thomas, and Showak, Walter, 1980. Zinc and zinc alloys. In Kirk-Othmer encyclopedia of Chemical Technology, 3rd. ed. Vol. 24, p. 824.

26. Lopat Enterprises, 1987. A Representative Selection of Laboratory Experiments and Reports of Full-Scale Commercial Use Which Demonstrate the Effectiveness of K-20 Lead-in-Soil Control System in Physical Chemical Solidification, Fixation, Encapsulation and Stabilization of Certain Contaminated Soil, Ash, Debris, and Similar Wastes.

27. Maczek, Helnut and Kola, Rolf, 1980. Recovery of zinc and lead from electric furnace steelmaking dust at Berzelius. Journal of Metals. 32:53-58.

28. Mishuck, E. Taylor, D.R., Telles, R. and Lubowitz, H. 1984. Encapsulation/ Fixation (E/F) mechanisms. Report No. DRXTH-TE-CR-84298. Prepared by S-Cubed under Contract No. DAAK11-81-C-0164.

29. Pojasek RB. 1979. "Solid-Waste Disposal: Solidification" Chemical Engineering 86(17): 141-145.

REFERENCES (continued)

30. Price, Laurence. Tensions Mount in EAF Dust Bowl. Metal Producing. February 1986.

31. SKF Plasmadust, Key Data for the Scandust Plant for Treating EAF Flue Dust (K061), August, 1987. (Industry Submitted Data)

32. St. Joe Flame Reactor Process for EAF Dust (Industry Submitted Data).

33. Sumitomo Corporation of America, On-site Treatment of EAF Dust Via the NMD System Using Sensible Heat From Molten Slag, 1987. (Industry submitted data)

APPENDICES

APPENDIX A

A.1 F Value Determination for ANOVA Test

As noted earlier in Section 1.0, EPA is using the statistical method known as analysis of variance in the determination of the level of performance that represents "best" treatment where more than one technology is demonstrated. This method provides a measure of the differences between data sets. If the differences are not statistically significant, the data sets are said to be homogeneous.

If the Agency found that the levels of performance for one or more technologies are not statistically different (i.e., the data sets are homogeneous), EPA would average the long term performance values achieved by each technology and then multiply this value by the largest variability factor associated with any of the acceptable technologies. If EPA found that one technology performs significantly better (i.e., the data sets are not homogeneous), BDAT would be the level of performance achieved by the best technology multiplied by its variability factor.

To determine whether any or all of the treatment performance data sets are homogeneous using the analysis of variance method, it is necessary to compare a calculated "F value" to what is known as a "critical value." (See Table A-1.) These critical values are available in most statistics texts (see, for example, Statistical Concepts and Methods by Bhattacharyya and Johnson, 1977, John Wiley Publications, New York).

Where the F value is less than the critical value, all treatment data sets are homogeneous. If the F value exceeds the critical value, it is

necessary to perform a "pair wise F" test to determine if any of the sets are homogeneous. The "pair wise F" test must be done for all of the various combinations of data sets using the same method and equation as the general F test.

The F value is calculated as follows:

(i) All data are natural logtransformed.

(ii) The sum of the data points for each data set is computed (T_i).

(iii) The statistical parameter known as the sum of the squares between data sets (SSB) is computed:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left(\left[\frac{\sum_{i=1}^{k} T_i}{N} \right]^2 \right)$$

where:

k = number of treatment technologies
n_i = number of data points for technology i
N = number of data points for all technologies
T_i = sum of natural logtransformed data points for each technology.

(iv) The sum of the squares within data sets (SSW) is computed:

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

where:

$x_{i,j}$ = the natural logtransformed observations (j) for treatment technology (i).

(v) The degrees of freedom corresponding to SSB and SSW are calculated. For SSB, the degree of freedom is given by k-1. For SSW, the degree of freedom is given by N-k.

(vi) Using the above parameters, the F value is calculated as follows:

$$F = \frac{MSB}{MSW}$$

where:

MSB = SSB/(k-1) and
MSW = SSW/(N-k).

A computational table summarizing the above parameters is shown below.

Computational Table for the F Value

Source	Degrees of freedom	Sum of squares	Mean square	F
Between	K-1	SSB	MSB = SSB/k-1	MSB/MSW
Within	N-k	SSW	MSW = SSW/N-k	

Below are three examples of the ANOVA calculation. The first two represent treatment by different technologies that achieve statistically similar treatment; the last example represents a case where one technology achieves significantly better treatment than the other technology.

Example 1
Methylene Chloride

Steam stripping				Biological treatment			
Influent (µg/l)	Effluent (µg/l)	ln(effluent)	[ln(effluent)]^2	Influent (µg/l)	Effluent (µg/l)	ln(effluent)	[ln(effluent)]^2
1550 00	10 00	2 30	5.29	1960 00	10 00	2.30	5 29
1290 00	10 00	2 30	5.29	2568 00	10.00	2.30	5 29
1640 00	10 00	2 30	5 29	1817 00	10.00	2 30	5 29
5100 00	12 00	2 48	6 15	1640.00	26 00	3.26	10 63
1450 00	10 00	2 30	5.29	3907 00	10.00	2.30	5.29
4600 00	10 00	2 30	5.29				
1700 00	10 00	2 30	5.29				
3400 00	10 00	2 30	5.29				
4600 00	10 00	2 30	5 29				
12100 00	10 00	2 30	5 29				
Sum							
-	-	23 18	53 76	-	-	12.46	31.79
Sample Size							
10	10	10	-	5	5	5	-
Mean							
3669	10 2	2 32	-	2378	13.2	2.49	-
Standard Deviation.							
3328 67	63	06	-	923 04	7.15	.43	-
Variability Factor							
	1 15	-	-	-	2 48	-	-

ANOVA Calculations.

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left(\left[\frac{\sum_{i=1}^{k} T_i}{N} \right]^2 \right)$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

$MSB = SSB/(k-1)$

$MSW = SSW/(N-k)$

Example 1 (continued)

F = MSB/MSW

where

k = number of treatment technologies

n_i = number of data points for technology i

N = number of natural log transformed data points for all technologies

T_i = sum of log transformed data points for each technology

X_{ij} = the nat log transformed observations (j) for treatment technology (i)

$n_1 = 10$, $n_2 = 5$, $N = 15$, $k = 2$, $T_1 = 23\ 18$, $T_2 = 12.46$, $T = 35\ 64$, $T^2 = 1270\ 21$

$T_1^2 = 537\ 31$ $T_2^2 = 155.25$

$$SSB = \left(\frac{537\ 31}{10} + \frac{155\ 25}{5} \right) - \frac{1270.21}{15} = 0.10$$

$$SSW = (53\ 76 + 31\ 79) - \left(\frac{537\ 31}{10} + \frac{155\ 25}{5} \right) = 0.77$$

MSB = 0 10/1 = 0 10

MSW = 0 77/13 = 0 06

$$F = \frac{0\ 10}{0.06} = 1\ 67$$

ANOVA Table

Source	Degrees of freedom	SS	MS	F
Between(B)	1	0.10	0 10	1.67
Within(W)	13	0.77	0.06	

The critical value of the F test at the 0 05 significance level is 4.67 Since the F value is less than the critical value, the means are not significantly different (i e., they are homogeneous)

Note All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations

Example 2
Trichloroethylene

Steam stripping				Biological treatment			
Influent (µg/l)	Effluent (µg/l)	ln(effluent)	[ln(effluent)]^2	Influent (µg/l)	Effluent (µg/l)	ln(effluent)	[ln(effluent)]^2
1650 00	10 00	2 30	5.29	200 00	10.00	2.30	5.29
5200 00	10 00	2 30	5 29	224.00	10.00	2.30	5.29
5000 00	10 00	2 30	5 29	134 00	10.00	2.30	5.29
1720 00	10 00	2 30	5 29	150 00	10.00	2.30	5.29
1560 00	10 00	2 30	5.29	484 00	16.25	2.79	7.78
10300 00	10 00	2.30	5 29	163 00	10.00	2.30	5 29
210 00	10 00	2 30	5.29	182 00	10.00	2.30	5.29
1600 00	27 00	3.30	10.89				
204 00	85 00	4 44	19.71				
160 00	10 00	2 30	5.29				
Sum							
-	-	26 14	72 92	-	-	16 59	39 52
Sample Size							
10	10	10	-	7	7	7	-
Mean							
2760	19.2	2 61	-	220	10 89	2.37	-
Standard Deviation							
3209 6	23 7	.71	-	120.5	2.36	19	-
Variability Factor.							
-	3 70	-	-	-	1 53	-	-

ANOVA Calculations

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left(\left[\frac{\sum_{i=1}^{k} T_i}{N} \right]^2 \right)$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

MSB = SSB/(k-1)

MSW = SSW/(N-k)

Example 2 (continued)

$F = MSB/MSW$

where

k = number of treatment technologies

n_i = number of data points for technology i

N = number of data points for all technologies

T_i = sum of natural log transformed data points for each technology

X_{ij} = the natural log transformed observations (j) for treatment technology (i)

$N_1 = 10$, $N_2 = 7$, $N = 17$, $k = 2$, $T_1 = 26.14$, $T_2 = 16.59$, $T = 42.73$, $T^2 = 1825.85$, $T_1^2 = 683.30$, $T_2^2 = 275.23$

$$SSB = \left\{\frac{683.30}{10} + \frac{275.23}{7}\right\} - \frac{1825.85}{17} = 0.25$$

$$SSW = (72.92 + 39.52) - \left\{\frac{683.30}{10} + \frac{275.23}{7}\right\} = 4.79$$

$MSB = 0.25/1 = 0.25$

$MSW = 4.79/15 = 0.32$

$$F = \frac{0.25}{0.32} = 0.78$$

ANOVA Table

Source	Degrees of freedom	SS	MS	F
Between(B)	1	0.25	0.25	0.78
Within(W)	15	4.79	0.32	

The critical value of the F test at the 0.05 significance level is 4.54. Since the F value is less than the critical value, the means are not significantly different (i.e., they are homogeneous).

Note All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

1790g

Example 3
Chlorobenzene

Activated sludge followed by carbon adsorption				Biological treatment			
Influent (µg/l)	Effluent (µg/l)	ln(effluent)	[ln(effluent)]^2	Influent (µg/l)	Effluent (µg/l)	ln(effluent)	ln[(effluent)]^2
7200 00	80 00	4 38	19 18	9206 00	1083 00	6.99	48 86
0500 00	70 00	4 25	18.06	16646.00	709 50	6.56	43 03
6075 00	65 00	4 56	12 67	49775 00	460.00	6.13	37.58
3040 00	10 00	2 30	5 29	14731 00	142 00	4.96	24 60
				3159 00	603.00	6.40	40.96
				6756.00	153.00	5 03	25 30
				3040 00	17.00	2.83	8.01
Sum							
-	-	14 49	55 20	-	-	38 90	228 34
Sample Size							
4	4	4	-	7	7	7	-
Mean							
5703	49	3.62	-	14759	452.5	5.56	-
Standard Deviation							
1835 4	32 24	95		16311.86	379.04	1 42	-
Variability Factor.							
-	7 00	-	-	-	15.79	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left(\left[\frac{\sum_{i=1}^{k} T_i}{N} \right]^2 \right)$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

$MSB = SSB/(k-1)$

$MSW = SSW/(N-k)$

$F = MSB/MSW$

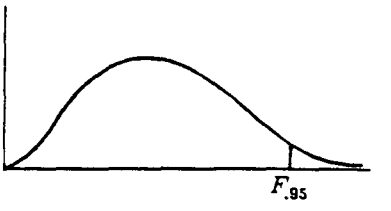
Table A-1

95th PERCENTILE VALUES FOR THE F DISTRIBUTION

n_1 = degrees of freedom for numerator

n_2 = degrees of freedom for denominator

(shaded area = .95)



n_2 \ n_1	1	2	3	4	5	6	8	12	16	20	30	40	50	100	∞
1	161.4	199.5	215.7	224.6	230.2	234.0	238.9	243.9	246.3	248.0	250.1	251.1	252.2	253.0	254.3
2	18.51	19.00	19.16	19.25	19.30	19.33	19.37	19.41	19.43	19.45	19.46	19.46	19.47	19.49	19.50
3	10.13	9.55	9.28	9.12	9.01	8.94	8.85	8.74	8.69	8.66	8.62	8.60	8.58	8.56	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.04	5.91	5.84	5.80	5.75	5.71	5.70	5.66	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.82	4.68	4.60	4.56	4.50	4.46	4.44	4.40	4.36
6	5.99	5.14	4.76	4.53	4.39	4.28	4.15	4.00	3.92	3.87	3.81	3.77	3.75	3.71	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.73	3.57	3.49	3.44	3.38	3.34	3.32	3.28	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.44	3.28	3.20	3.15	3.08	3.05	3.03	2.98	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.23	3.07	2.98	2.93	2.86	2.82	2.80	2.76	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.07	2.91	2.82	2.77	2.70	2.67	2.64	2.59	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	2.95	2.79	2.70	2.65	2.57	2.53	2.50	2.45	2.40
12	4.75	3.89	3.49	3.26	3.11	3.00	2.85	2.69	2.60	2.54	2.46	2.42	2.40	2.35	2.30
13	4.67	3.81	3.41	3.18	3.03	2.92	2.77	2.60	2.51	2.46	2.38	2.34	2.32	2.26	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.70	2.53	2.44	2.39	2.31	2.27	2.24	2.19	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.64	2.48	2.39	2.33	2.25	2.21	2.18	2.12	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.59	2.42	2.33	2.28	2.20	2.16	2.13	2.07	2.01
17	4.45	3.59	3.20	2.96	2.81	2.70	2.55	2.38	2.29	2.23	2.15	2.11	2.08	2.02	1.96
18	4.41	3.55	3.16	2.93	2.77	2.66	2.51	2.34	2.25	2.19	2.11	2.07	2.04	1.98	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.48	2.31	2.21	2.15	2.07	2.02	2.00	1.94	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.45	2.28	2.18	2.12	2.04	1.99	1.96	1.90	1.84
22	4.30	3.44	3.05	2.82	2.66	2.55	2.40	2.23	2.13	2.07	1.98	1.93	1.91	1.84	1.78
24	4.26	3.40	3.01	2.78	2.62	2.51	2.36	2.18	2.09	2.03	1.94	1.89	1.86	1.80	1.73
26	4.23	3.37	2.98	2.74	2.59	2.47	2.32	2.15	2.05	1.99	1.90	1.85	1.82	1.76	1.69
28	4.20	3.34	2.95	2.71	2.56	2.45	2.29	2.12	2.02	1.96	1.87	1.81	1.78	1.72	1.65
30	4.17	3.32	2.92	2.69	2.53	2.42	2.27	2.09	1.99	1.93	1.84	1.79	1.76	1.69	1.62
40	4.08	3.23	2.84	2.61	2.45	2.34	2.18	2.00	1.90	1.84	1.74	1.69	1.66	1.59	1.51
50	4.03	3.18	2.79	2.56	2.40	2.29	2.13	1.95	1.85	1.78	1.69	1.63	1.60	1.52	1.44
60	4.00	3.15	2.76	2.53	2.37	2.25	2.10	1.92	1.81	1.75	1.65	1.59	1.56	1.48	1.39
70	3.98	3.13	2.74	2.50	2.35	2.23	2.07	1.89	1.79	1.72	1.62	1.56	1.53	1.45	1.35
80	3.96	3.11	2.72	2.48	2.33	2.21	2.05	1.88	1.77	1.70	1.60	1.54	1.51	1.42	1.32
100	3.94	3.09	2.70	2.46	2.30	2.19	2.03	1.85	1.75	1.68	1.57	1.51	1.48	1.39	1.28
150	3.91	3.06	2.67	2.43	2.27	2.16	2.00	1.82	1.71	1.64	1.54	1.47	1.44	1.34	1.22
200	3.89	3.04	2.65	2.41	2.26	2.14	1.98	1.80	1.69	1.62	1.52	1.45	1.42	1.32	1.19
400	3.86	3.02	2.62	2.39	2.23	2.12	1.96	1.78	1.67	1.60	1.49	1.42	1.38	1.28	1.13
∞	3.84	2.99	2.60	2.37	2.21	2.09	1.94	1.75	1.64	1.57	1.46	1.40	1.32	1.24	1.00

Example 3 (continued)

where,

k = number of treatment technologies

n_i = number of data points for technology i

N = number of data points for all technologies

T_i = sum of natural log transformed data points for each technology

X_{ij} = the natural log transformed observations (j) for treatment technology (i)

$N_1 = 4$, $N_2 = 7$, $N = 11$, $k = 2$, $T_1 = 14.49$, $T_2 = 38.90$, $T = 53.39$, $T^2 = 2850.49$, $T_1^2 = 209.96$

$T_2^2 = 1513.21$

$$SSB = \left\{\frac{209.96}{4} + \frac{1513.21}{7}\right\} - \frac{2850.49}{11} = 9.52$$

$$SSW = (55.20 + 228.34) - \left\{\frac{209.96}{4} + \frac{1513.21}{7}\right\} = 14.88$$

$MSB = 9.52/1 = 9.52$

$MSW = 14.88/9 = 1.65$

$F = 9.52/1.65 = 5.77$

ANOVA Table

Source	Degrees of freedom	SS	MS	F
Between(B)	1	9.53	9.53	5.77
Within(W)	9	14.89	1.65	

The critical value of the F test at the 0.05 significance level is 5.12. Since the F value is larger than the critical value, the means are significantly different (i.e., they are heterogeneous)

Note. All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

A.2. Variability Factor

$$VF = \frac{C_{99}}{Mean}$$

where:

VF = estimate of daily maximum variability factor determined from a sample population of daily data.

C_{99} = Estimate of performance values for which 99 percent of the daily observations will be below. C_{99} is calculated using the following equation: $C_{99} = Exp(y + 2.33\ Sy)$ where y and Sy are the mean and standard deviation, respectively, of the logtransformed data.

Mean = average of the individual performance values.

EPA is establishing this figure as an instantaneous maximum because the Agency believes that on a day-to-day basis the waste should meet the applicable treatment standards. In addition, establishing this requirement makes it easier to check compliance on a single day. The 99th percentile is appropriate because it accounts for almost all process variability.

In several cases, all the results from analysis of the residuals from BDAT treatment are found at concentrations less than the detection limit. In such cases, all the actual concentration values are considered unknown and hence, cannot be used to estimate the variability factor of the analytical results. Below is a description of EPA's approach for calculating the variability factor for such cases with all concentrations below the detection limit.

It has been postulated as a general rule that a lognormal distribution adequately describes the variation among concentrations. Agency data shows that the treatment residual concentrations are

distributed approximately lognormally. Therefore, the lognormal model has been used routinely in the EPA development of numerous regulations in the Effluent Guidelines program and is being used in the BDAT program. The variability factor (VF) was defined as the ratio of the 99th percentile (C_{99}) of the lognormal distribution to its arithmetic mean (Mean).

$$VF = \frac{C_{99}}{Mean} \qquad (1)$$

The relationship between the parameters of the lognormal distribution and the parameters of the normal distribution created by taking the natural logarithms of the lognormally-distributed concentrations can be found in most mathematical statistics texts (see for example: Distribution in Statistics-Volume 1 by Johnson and Kotz, 1970). The mean of the lognormal distribution can be expressed in terms of the mean (μ) and standard deviation (σ) of the normal distribution as follows:

$$C_{99} = \text{Exp}\ (\mu + 2.33\sigma) \qquad (2)$$

$$\text{Mean} = \text{Exp}\ (\mu + .5\sigma^2) \qquad (3)$$

Substituting (2) and (3) in (1) the variability factor can then be expressed in terms of σ as follows:

$$VF = \text{Exp}\ (2.33\ \sigma - .5\sigma^2) \qquad (4)$$

For residuals with concentrations that are not all below the detection limit, the 99th percentile and the mean can be estimated from the actual analytical data and accordingly, the variability factor (VF) can be estimated using equation (1). For residuals with concentrations

that are below the detection limit, the above equations can be used in conjunction with the assumptions below to develop a variability factor.

Step 1: The actual concentrations follow a lognormal distribution. The upper limit (UL) is equal to the detection limit. The lower limit (LL) is assumed to be equal to one tenth of the detection limit. This assumption is based on the fact that data from well-designed and well-operated treatment systems generally falls within one order of magnitude.

Step 2: The natural logarithms of the concentrations have a normal distribution with an upper limit equal to ln (UL) and a lower limit equal to ln (LL).

Step 3: The standard deviation (σ) of the normal distribution is approximated by

$$\sigma = [(\ln (UL) - \ln (LL)] / [(2)(2.33)] = [\ln(UL/LL)] / 4.66$$

when $LL = (0.1)(UL)$ then $\sigma = (\ln 10) / 4.66 = 0.494$

Step 4: Substitution of the value from Step 3 in equation (4) yields the variability factor, VF.

$$VF = 2.8$$

APPENDIX B - ANALYTICAL QA/QC

From Onsite Engineering Report
for Horsehead Resource Development Co., Inc.

APPENDIX B

Analytical Methods

Analytical Method	Method Number	Reference
Metals		
Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by Flame Atomic Absorption Spectroscopy (AA) or Inductivily Coupled Plasma Spectroscopy (ICP)	3010	1
Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by Furnace Atomic Absorption Spectroscopy (AA)	3020	1
Acid Digestion of Sediments, Sludges, and soils	3050	1
Inductively Coupled Plasma Atomic Emission Spectroscopy (Cadmium, Chromium, Lead, Zinc)	6010	1
Mercury in Liquid Waste (Manual Cold-Vapor Technique)	7471	1
Toxicity Characteristic Leaching Procedure (TCLP)	51 FR 40643	2

References

1 Environmental Protection Agency. 1986. Test Methods for Evaluating Solid Waste. Third Edition. U S. EPA Office of Solid Waste and Emergency Response November 1986.

2 Federal Register. 1986. Hazardous Waste Management Systems, Land Disposal Restrictions, Final Rule; Appendix I to Part 268 - Toxicity Leaching Procedure (TCLP). Vol. 51, No. 216 November 7, 1986 pp 40643-40654.

Specific Procedures or Equipment Used in Analysis of Metals
When Alternative or Equivalents Allowed in the SW-846 Methods

Analysis	SW-846 Method	Equipment	Alternative or Equivalent Allowed by SW-846 Methods	Specific Procedures or Equipment Used
Inductively coupled plasma atomic emission spectroscopy	6010	Jarrell Ash 1140	• Operate equipment following instructions provided by instument's manufacturer • For operation with organic solvents, auxilliary argon gas inlet is recommended.	• Equipment operated using procedures specified in the Jarrell Ash (JA) 1140 Operator's Manual. • Auxiliary argon gas was not required for sample matrix analyzed
Mercury	7471	Perkin Elmer 50A	• Operate equipment following instructions by instrument's manufacturer • Cold vapor apparatus is described in SW-846 or an equivalent apparatus may be used • Sample may be prepared using the water bath method or the autoclave method described in SW-846	• Equipment operated using procedures specified in Perkin Elmer 50A Instructions Manual • Mercury was analyzed by cold vapor method using the apparatus as specified in SW-846 except, there was no scrubber. • Samples were prepared using the water bath method

Specific Procedures or Equipment Used in Analysis of Metals
When Alternative or Equivalents Allowed in the SW-846 Methods
(continued)

Analysis	SW-846 Method	Equipment	Alternative or Equivalent Allowed by SW-846 Methods	Specific Procedures or Equipment Used
Acid Digestion for metals analyzed	3010	-	• Digest 100 ml of sample in a conical beaker	• Initial sample volume of 50 ml is digested in Griffin straight-side beakers. All acids and peroxides are halved.

Duplicate Analysis for the Total Composition
Sample from S6:Residual Slag Material[1]

BDAT Metals	Sample Set 1 (mg/kg)	Sample Set 1 (mg/kg)	Relative percent difference (RPD)*
Chromium	662	752	13
Lead	1,720	1,780	3
Zinc	24,300	25,800	6

*RPD = [(S1-S2)/((S1+S2)/2)] x 100%, where S1 is the larger of the two observed values.

1 - Duplicates not run constitutes not detected in any of the treated samples (cadmium, mercury).

Duplicate Analysis for Matrix Spikes for TCLP Extract
for Sample Point 6: Residual Slag Material

BDAT Metals**	Sample Set 4 (ug/l)	Sample Set 4 (ug/l)	Relative percent difference (RPD)*
Cadmium	26	27	4
Chromium	35	34	3
Lead	22	19	15
Mercury	0.9	1.1	20
Zinc	12,600	12,400	2

NC = Not Calculatable

*RPD = [(S1-S2)/((S1+S2)/2)] x 100%, where S1 is the larger of the two observed values.

BDAT Constituents for Spiking Mixture for Total Composition Sample and for TCLP Extract Sample

Constituent	Total Composition Spike Concentration (mg/Kg)	TCLP Extract Spike Concentration (ug/l)
Metals		
Cadmium	2.5	25
Chromium	2,000	50
Lead	500	25
Mercury	0.5	1
Zinc	6,000	1,000

Matrix Spike Recoveries for Treated Waste Total Concentrations and Accuracy Correction Factors for High Temperature Metals Recovery

BDAT constituent	Original amount found (mg/kg)	Sample			Sample duplicate			Correction Factor
		Spike added (mg/kg)	Spike result (mg/kg)	Percent recovery*	Spike added (mg/kg)	Spike result (mg/kg)	Percent recovery*	
Cadmium	<1.5	2.5	<1.5	NC	2.5	2.4	96	1.04
Chromium	978	2,000	2,970	100	2,000	2,870	95	1.05
Lead	365	500	683	64	500	705	68	1.56
Mercury	<0.1	0.5	0.5	100	0.5	0.5	100	1.00
Zinc	4,680	6,000	9,770	85	6,000	9,950	88	1.18

NC = Not Calculatable.

*Percent Recovery = [(Spike Result - Original Amount)/Spike Added] x 100.

Matrix Spike Recovery for TCLP Extract for Treated Waste and Accuracy Correction Factors
for High Temperature Metals Recovery

BDAT constituent	Original sample (ug/l)	Sample			Sample duplicate		Correction Factor
		Spike added (ug/l)	Spike result (ug/l)	Percent recovery*	Spike result (ug/l)	Percent recovery*	
Cadmium	4.2	25	26	87	27	91	1.15
Chromium	<4.0	50	35	70	34	68	1.47
Lead	<5.0	25	22	88	19	76	1.32
Mercury	<0.2	1.0	0.9	90	1.1	110	1.11
Zinc	2,640	10,000	12,600	100	12,400	98	1.02

Percent Recovery = [(Spike Result - Original Amount)/Spike Added] 100.

Calibration Procedures Used to Analyze Organic and Inorganic BDAT Constituents

Analysis	SW-846 method	Standards	Calibration Procedures
Inductively Coupled Plasma Atomic Emission spectroscopy	6010	• Calibration Standards for ICP - calibration blank; antimony, barium, beryllium, cadmium, chromium, copper, lead, nickel, selenium, silver, thallium, zinc, aluminum, arsenic, boron, calcium, cobalt, iron, magnesium, manganese, silicon, tin, and vanadium at 1 ppm; sodium at 10 ppm; potassium and iron at 50 ppm;	• Initial calibration verification was run at beginning of each batch. The concentrations are barium at 1,980 ppb, beryllium at 481 ppb, cadmium at 489 ppb, chromium at 506 ppb, copper at 542 ppb, lead at 4,510 ppb, nickel at 496 ppb, silver at 509 ppb, vanadium at 511 ppb, zinc at 3,100 ppb, aluminum at 1,980 ppb, calcium at 49,800 ppb, cobalt at 542 ppb, iron at 1,990 ppb, magnesium at 25,000 ppb, manganese at 513 ppb, potassium at 50,200 ppb, and sodium at 50,700 ppb.. This meets the requirements in SW-846.
		• Instrument check samples contained all the elements to be analyzed by method 6010.	• Instrument check samples were used at a frequency of 10 percent. The concentration is at 500 ppb for antimony, barium, beryllium, cadmium, chromium, copper, nickel, silver, vanadium, and zinc, aluminum, arsenic, boron, calcium, cobalt, iron, magnesium, manganese, and silicon; lead at 1000 ppb; selenium, thallium, and tin at 2,000 ppb; potassium and sodium at 20,000 ppb. This meets the require- ments specified in SW-846.
Mercury in Liquid Waste (Manual Cold-Vapor Technique)	7470	• Calibration standards for mercury were a blank, 0.5 ppb, 2 ppb, 5 ppb and 10 ppb.	• The calibration curve was run once per day. This meets the requirements in SW-846. • The concentration of the check standard was 5.0 ug/l and it was run at a 10 percent frequency. This meets the requirements in SW-846.

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Source and Purity of Calibration Standards

	Constituents	Source for Standards	Purity or Grade or Concentration
BDAT Metals			
158	Cadmium	Aesar	1000 ppm
159	Chromium (total)	Aesar	1000 ppm
162	Lead	Aesar	1000 ppm
163	Mercury	Aesar	1000 ppm
169	Zinc	Aesar	1000 ppm

Source and/or Purity of System Performance
Check Compounds and Calibration Check Standards

Compound	EPA Check Standard	Purity/Grade
Method 6010: Inductively Coupled Plasma Atomic Emission Spectroscopy		
Calibration Check Compounds		
ICP metals[1]	UNLV ICV1	*
Mercury - ICV5	UNLV ICV5	*

[1] Check standard contains cadmium, chromium, lead, and zinc.

* EPA check standard with certified high purity level.

UNLV - University of Nevada at Las Vegas
ICV - Initial calibration verification.

APPENDIX C

Kiln Temperature Strip Charts

This information has been claimed CBI by
the facility pursuant to 40 CFR Part 2

APPENDIX D

Statistical Analysis

ANOVA - High Temperature Metals Recovery/Stabilization

APPENDIX D

Statistical Analysis of High Temperature Metals Recovery
EPA Collected Data - Accuracy Corrected Values

Pollutant	Treated Waste (ppm) SS #3	SS #4	SS #7	$\bar{X}$	$\bar{Y}$	Sy	VF
Cd (TOT)	<15 6	<15.6	<15.6	15 6	2 747	0	2 8
Cd (TCLP)	<0.069	<0.069	<0 069	0 069	-2.674	0	2.8
Cr (TOT)	785	1,027	500	771	6.605	0.364	2 24
Cr (TCLP)	<0 118	<0.118	<0.118	0.118	-2.137	0	2.8
Pb (TOT)	3,026	569	3,697	2.431	7.525	1 027	8.35
Pb (TCLP)	<0 033	<0.033	<0 033	0 033	-3.411	0	2 8
Hg (TOT)	<0.1	<0.1	<0.1	0 1	-2 307	0	2.8
Hg (TCLP)	<0 0002	0.0030	<0 0002	0.0011	-7.614	1.563	17.13
Zn (TOT)	13,216	5,522	5,369	8,036	8.898	0.512	3 00
Zn (TCLP)	0.246	0 131	0.082	0 153	-1.979	0 551	3.28

Mean of x, $\bar{X} = \frac{\Sigma x}{n}$

Mean of y, $\bar{Y} = \frac{\Sigma y}{n}$

Standard Deviation $Sy = \left(\frac{\Sigma (y-\bar{y})^2}{n-1} \right)^{\frac{1}{2}}$

$VF = \text{Exp} (\bar{Y} + 2\ 33 * Sy)/\bar{X}$

Statistical Analysis of Stabilization (Lime/Fly Ash)
EPA Collected Data - Accuracy Corrected Values

Pollutant	Treated Waste (ppm) SS #7	SS #8	SS #9	$\bar{X}$	$\bar{Y}$	Sy	VF
Cd (TCLP)	0 036	0.053	0.080	0.056	-2.919	0.399	2.42
Cr (TCLP)	0 113	0.087	0.065	0.088	-2 452	0.277	1 86
Pb (TCLP)	0.140	0.064	0.061	0.088	-2.504	0.4664	2.74
Hg (TCLP)	0 0015	0 0015	0.0016	0 002	-6.481	0.037	1.11
Zn (TCLP)	0 681	0.206	0 458	0.448	-0.915	0.609	3.69

Mean of x, $\bar{X} = \frac{\Sigma x}{n}$

Mean of y, $\bar{Y} = \frac{\Sigma y}{n}$

Standard Deviation Sy $= \left(\frac{\Sigma (y-\bar{y})^2}{n-1} \right)^{\frac{1}{2}}$

VF = Exp $(\bar{Y} + 2.33 * Sy)/\bar{X}$

Cd

ANALYSIS OF VARIANCE RESULTS

Variable LNCONC (LN(CONCENTRATION))
By Variable TREAT

Source	D F	Sum of Squares	Mean Squares	Computed F	Tabulated F	Decision
Between Groups	1	0 0979	0 0979	1.228	7.22	No statistical difference
Within Groups	4	0 3189	0.0797			
Total	5	0 4166				

Cr

ANALYSIS OF VARIANCE RESULTS

Variable LNCONC (LN(CONCENTRATION))
By Variable TREAT

Source	D F	Sum of Squares	Mean Squares	Computed F	Tabulated F	Decision
Between Groups	1	0 1486	0 1486	3.885	7.22	No statistical difference
Within Groups	4	0 1531	0.0383			
Total	5	0.3017				

Pb

ANALYSIS OF VARIANCE RESULTS

Variable LNCONC (LN(CONCENTRATION))
By Variable TREAT

Source	D F.	Sum of Squares	Mean Squares	Computed F	Tabulated F	Decision
Between Groups	1	1 2348	1.2348	11.3525	7.22	There is a significant difference between the two High temperature metals recovery is better.
Within Groups	4	0 4351	0.1088			
Total	5	1.6698				

Hg

ANALYSIS OF VARIANCE RESULTS

Variable LNCONC (LN(CONCENTRATION))
By Variable TREAT

Source	D F.	Sum of Squares	Mean Squares	Computed F	Tabulated F	Decision
Between Groups	1	2 0493	2 0493	1.8141	7.22	No statistical difference
Within Groups	4	4 5188	1.1297			
Total	5	6 5681				

Zn

ANALYSIS OF VARIANCE RESULTS

Variable LNCONC (LN(CONCENTRATION))
By Variable TREAT

Source	D F	Sum of Squares	Mean Squares	Computed F	Tabulated F	Decision
Between Groups	1	2 6877	2.6877	7 9689	7.22	There is a significant difference between the two High temperature metals recovery is better
Within Groups	4	1 3474	0 3368			
Total	5	4 0351				

APPENDIX E

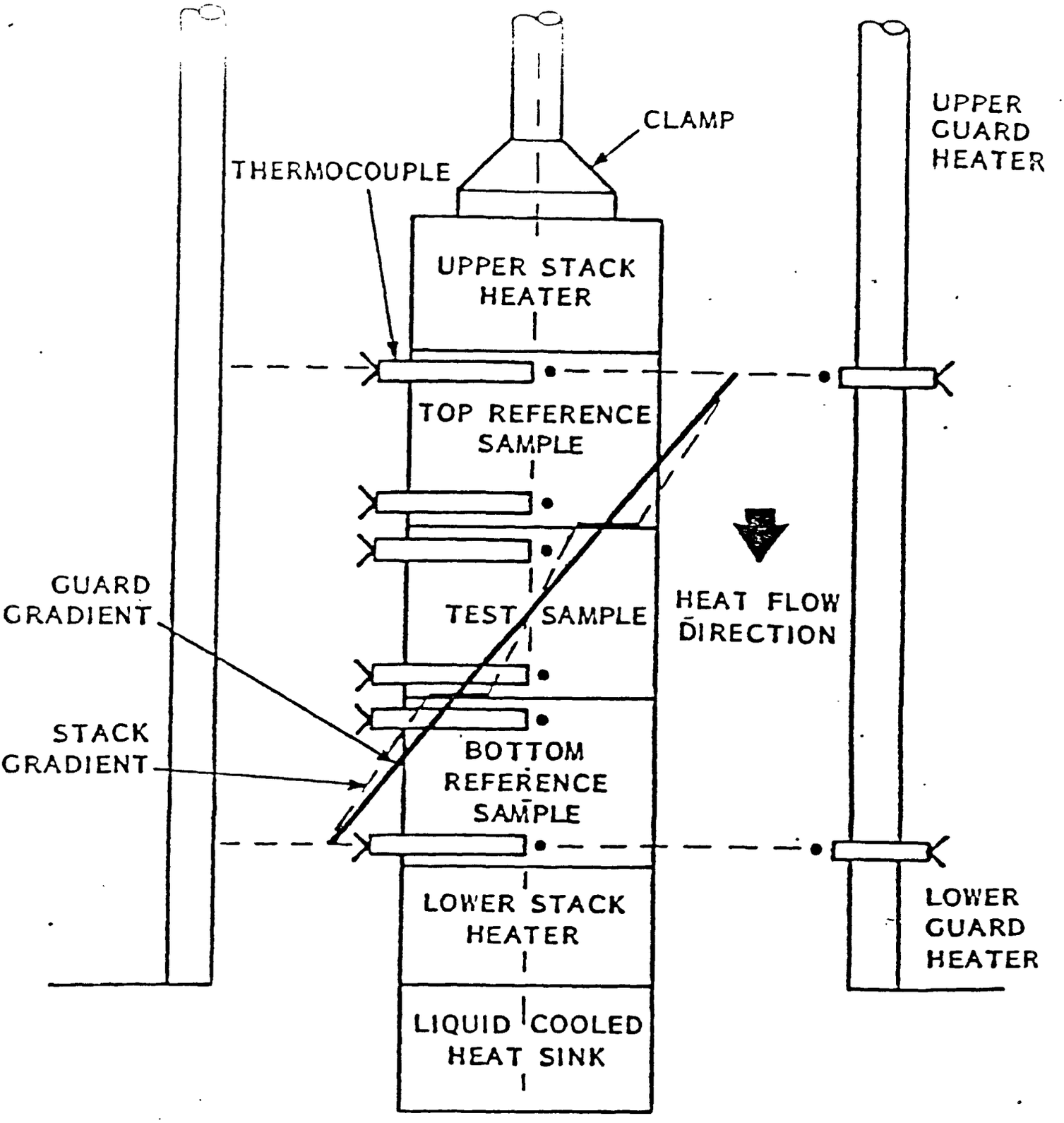
Analytical Method for Determining the Thermal Conductivity of a Waste

APPENDIX E

The comparative method of measuring thermal conductivity has been proposed as an ASTM test method under the name "Guarded, Comparative, Longitudinal Heat Flow Technique." A thermal heat flow circuit is used which is the analog of an electrical circuit with resistances in series. A reference material is chosen to have a thermal conductivity close to that estimated for the sample. Reference standards (also known as heat meters) having the same cross-sectional dimensions as the sample are placed above and below the sample. An upper heater, a lower heater, and a heat sink are added to the "stack" to complete the heat flow circuit. See Figure 1.

The temperature gradients (analogous to potential differences) along the stack are measured with type K (chromel/alumel) thermocouples placed at known separations. The thermocouples are placed into holes or grooves in the references and also in the sample whenever the sample is thick enough to accommodate them.

For molten samples, pastes, greases, and other materials that must be contained, the material is placed into a cell consisting of a top and bottom of Pyrex 7740 and a containment ring of marinite. The sample is 2 inch in diameter and .5 inch thick. Thermocouples are not placed into the sample but rather the temperatures measured in the Pyrex are extrapolated to give the temperature at the top and bottom surfaces of the sample material. The Pyrex disks also serve as the thermal conductivity reference material.



SCHEMATIC DIAGRAM OF THE COMPARATIVE METHOD

The stack is clamped with a reproducible load to insure intimate contact between the components. In order to produce a linear flow of heat down the stack and reduce the amount of heat that flows radially, a guard tube is placed around the stack and the intervening space is filled with insulating grains or powder. The temperature gradient in the guard is matched to that in the stack to further reduce radial heat flow.

The comparative method is a steady state method of measuring thermal conductivity. When equilibrium is reached the heat flux (analogous to current flow) down the stack can be determined from the references. The heat into the sample is given by

$$Q_{in} = \lambda_{top}(dT/dx)_{top}$$

and the heat out of the sample is given by

$$Q_{out} = \lambda_{bottom}(dT/dx)_{bottom}$$

where

λ = thermal conductivity

dT/dx = temperature gradient

and top refers to the upper reference while bottom refers to the lower reference. If the heat was confined to flow just down the stack, then Q_{in} and Q_{out} would be equal. If Q_{in} and Q_{out} are in reasonable agreement, the average heat flow is calculated from

$$Q = (Q_{in} + Q_{out})/2$$

The sample thermal conductivity is then found from

$$\lambda_{sample} = Q/(dT/dx)_{sample}$$